



## TEACH FOOD – Developing a teacher’s community of practice

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## Table of content

<b>Title</b>	<b>Page</b>
<b>Benefits of using podcasts as supplementary teaching material</b> Reynir Smari Atlason, University of Southern Denmark, Denmark	4
<b>Technology as Panacea!? Improvised Skits that Tackle Water Contamination Across the Centuries.</b> André Baier, Technische Universität Berlin, Germany	8
<b>Engineering Conferences - An Innovative Course for Master Students in Engineering</b> Matthias Neef, Thomas Zielke, Claudia Fussenecker , Düsseldorf University of Applied Sciences, Germany	13
<b>Expert in Teams Course Demands Work on Real Problems</b> Erik Skov Madsen, University of Southern Denmark,	25
<b>Experts in Teams - An experiential learning method</b> Steffen Kjær Johansen, University of Southern Denmark	31
<b>Death by x and y – a mathematician’s lament</b> Per Skaftø Hansen, DTU	40
<b>TEACH FOOD – Developing a teacher’s community of practice</b> Lene Duedahl-Olesen, Håkan Vigre, Pernille Andersson, Lars Bogø Jensen, DTU	48

# Benefits of using podcasts as supplementary teaching material

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## ABSTRACT

In a multidisciplinary class, it is difficult to avoid covering a topic a group of students have already encountered previously. To avoid this, supplementary material can be provided to students. By doing this, the teacher can engage directly into deeper theoretical or practical work and minimize amount of time covering introductory material. It was the intent of this study to develop teaching material for students which could be studied while riding bicycles. This was achieved by recording podcasts where pre-requisite material was covered in a popular manner, allowing students to listen to the recordings through mobile phones while riding bicycles. By doing so, students can avoid investing primary time into learning, but could use time that was already spent on activities. Four recordings were made, ranging in length between 10 to 18 minutes. The recordings are then made available to students through an online platform, accessible through mobile devices. It was found that students who did not have the most suitable background found their understanding of the material to increase if the Podcasts had been listened to.

*Keywords* – Podcasts; Flipped learning; E-learning

## I INTRODUCTION

In a multidisciplinary class, it may prove difficult to avoid introduction of material trivial to some, or many participants. One method to address this is to provide relevant reading material to students who lack the relevant background. Doing so does however increase the workload of those students which becomes unproportioned with regards to other students. Another way is to provide the students with video material to be viewed in their free time. Videos do however require the student to dedicate equal amount of time to them as they are long. The ideal situation would allow the student to get acquainted with the missing material without feeling that the workload is increased. The same situation should avoid prime-time being invested in the process of learning the missing material. In order to continue with such discussion, a qualitative assessment of time is needed. We can state that Saturday evenings are valued highly by most, while Tuesday afternoons are perhaps valued less. One also needs to take into consideration what is being done during the time. If one is conversing with a leader of the free-world, the time is valued higher than the time used for cleaning ones apartment. We would therefore like to provide a platform for students to invest non-prime time to the learning. Podcasts can be seen as a suitable way to accomplish this. Podcasts are much like radio shows. The only difference is that they are accessible on the internet and are generally not broadcasted live. The listener can therefore choose when he listens to the show. One way to listen to Podcasts is when the listener is commuting. This allow the listener to invest a non-prime time into getting acquainted with the material at hand. This paper focuses on this feature, where introductory material was recorded in a Podcast format for commuting students to listen to.

The class under study consists mainly of engineers with two types of backgrounds, a) Environmental engineering, and b) Product development and Innovation (PDI). Environmental engineers do have a background in various environmental assessments, while product development engineers generally do not. Introductory material to environmental assessments therefore needs to be given to PDI engineers, material that can in some cases be trivial to environmental engineers. In this paper, the aim is to provide introductory material through alternative online means. The research question addressed in this study is therefore:

a) Are podcasts a suitable method for delivering introductory material in a multi-disciplinary class?

b) Do students find themselves gaining content understanding using non-traditional methods of educational content delivery?

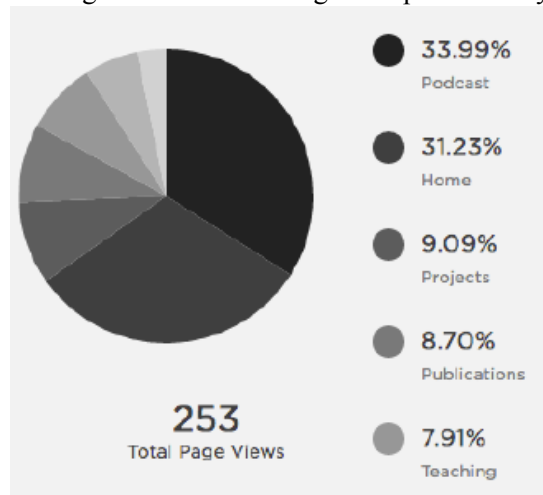
Using conventional flipped learning methods, where videos are recorded require students to use primary time watching the computer screen (Hwang et al., 2015). Here, an experiment is done using podcasts, where secondary time can be used for learning, for example while bicycling.

Danish cities in boast good infrastructure and a culture of bicycling as means of commuting. The time people ride bicycles is generally not used to conduct practical matters, and conventionally not to conduct university studies. It was the intent of this study to develop teaching material for students which could be studied while riding bicycles. This was achieved by recording podcasts where pre-requisite material was covered in a popular manner, allowing students to listen to the recordings through mobile phones while riding bicycles. By doing so, students can avoid investing primary time into learning, but could use time that was already spent on activities (Moura, 2008).

## II METHODS

Recordings were made using Audacity, a free audio recording platform (Audacity, 2013). In order to obtain good sound quality, an M-One USB condenser microphone was used. The podcasts then follow the following overall script. First, a light jazz intro is played followed by an introduction to the topic. The second half of the podcast was then devoted to interview a researcher in the field which the particular podcast episode covers. Four key topics were covered through podcast recordings. 1) Electronic waste with Keshav Parajuly 2) Circular Economy with Henrik Grüttner 3) Life Cycle Assessment with Hafþór Sigurjónsson and 4) Product development implementation where Tony Baho, a senior designer at Volvo was interviewed. Each episode was designed to be long enough to cover the essential core of the topic at hand but short enough to be listened to while commuting on a bicycle (Milakis et al., 2015). The duration of the shortest podcast was 10:18 and the longest 18:05. The recordings were then uploaded to <http://www.reyniratlason.com>, where the podcasts could only be accessed with a password. The password in this case was “sustainability”. By uploading the podcasts to a personal website, and restricting access, it was possible to monitor traffic through this particular part of the website.

Through traffic monitoring on <http://www.reyniratlason.com> it can be seen that traffic increases from



**Figure 1. A pie chart indicating where visitors navigate within <http://www.reyniratlason.com>**

August throughout October. In fact, it can be seen that 30% went to the Podcast part of the website. This number should however be added to the part which visited the “Home” part of the website, as visitors are automatically navigated there before accessing the podcasts. As can be seen in Figure 1, one can estimate that roughly 65% of visitors went to the podcast part of the website. In September, 30 individual visits from separate computers or mobile devices were made to the website, resulting in approximately 19 visits by different individuals to the podcast section. Using the same method, one can estimate that 17 individuals visited the podcast section in October. The class consists of 40 students. This indicates that a little less than half of the class took the initiative to listen to the podcasts.

In order to visualize if students found the content, or its delivery method to be of value, an online questionnaire was distributed and analyzed. Students were asked to evaluate their understanding of certain topics which had already been covered in class. Some of those topics had been introduced through the podcasts, while others had only been covered in class. Students were asked to rate their perceived understanding of the material on



a scale from 1-4. A rating of one indicates no-understanding of the material while 4 indicates a large increase in perceived understanding. Students (n=17) were asked to indicate if they had listened to the podcast, and if so then which episodes. Finally, students were asked to indicate their engineering background. Results were statistically analyzed in order to visualize if the podcasts had an effect on students perceived understanding of the material at hand and if students found themselves understanding the material covered in the podcasts better than material only covered in class.

### III RESULTS

Composing and recording a podcast is a more time consuming endeavor than initially assumed. It was found that each episode composed of approximately 5 hours of work. This included deciding the topic, creating a rough manuscript, locating a relevant person for an interview, conducting the interview and then finally editing the episode before uploading to the website. It was furthermore experienced that a certain level of stage fright became apparent from the author after uploading a podcast online. This was however shadowed by the positive response from the students, who indicated their liking of the material in class. More podcasts were even required by some students.

In Table 1, one can see averages on how students graded their perceived understanding of the topics covered by the podcasts. It should be noted that the sample of students participating in the survey was small, limiting the possible conclusions from this study. However, it can be seen that there seems to be no significance for students with environmental engineering background. This may be because of their previous education, and that they have very likely been exposed by the material previously. However, the PDI engineers, who were the target group, found themselves to understand the topics at hand better if they had in fact listened to the podcasts. The difference can be seen clearly when looking at the topic of E-waste, where those who did not listen to the podcast found themselves with a marginal increased understanding of the topic, scoring on average 2. Those who listened to the topic did however score on average 3.3, indicating a deeper understanding. In fact, PDI students found themselves understanding all topics better if they listened to the podcasts.

**Table 1. Average rating of perceived understanding between students based on engineering background**

	Did not listen (All)	Listened (All)	Did not listen (Env.)	Listened (Env.)	Did not listen (PDI)	Listened (PDI)
E Waste (Episode 1)	2.1	2.3	2.2	1.3	2.0	3.3
Circular Economy (Episode 2)	1.9	1.8	2.0	1.3	1.8	2.3
LCA (Episode 3)	2.3	2.0	1.8	1.0	2.7	3.0
Practical implementation (Episode 4)	2.9	3.5	2.6	3.3	3.2	3.7

### VII CONCLUSIONS

In correlation with previous studies, podcasts were found to be a suitable method for delivering introductory material in a multi-disciplinary class (Kratochwill et al., 2016; Liao et al., 2013). It was found that approximately 50% of students used the opportunity and engaged with the material. This research however suffers from a small sample size of students evaluating the learning outcome from the podcasts, limiting the conclusions to be made from this study.

Students with a PDI engineering background, were found to gain a deeper understanding of the topic at hand if they had listened to the podcasts. It can therefore be assumed that podcasts are potentially a valuable tool to provide relevant background material some students may be lacking. Locating which material that may however be is another matter and a subject for a future study.

After the test semester had finished, several students reached out with ideas on the future developments of the podcast. The suggestions included topics, music themes and relevant people to interview.

It was found that podcasts allowed students to use secondary time to gain basic understanding of certain topics. There are therefore no hurdles in using the same method for other classes taught by the author. Another class, “Consumer product testing and optimisation”, partially taught by the author is also consisting of engineers from various backgrounds. The class may therefore be well suited for podcasts, where students gain deeper knowledge about certain aspects taught in class.

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## **BIOGRAPHICAL INFORMATION**

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**Technology as Panacea!?**  
**Improvised Skits that Tackle Water Contamination Across the Centuries.**

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**Extended Abstract for a Hands-on-Session**

*Keywords* - technological fixes, history of technology, ethics of technology, theater play, power relations, society-nature relations

**Abstract**

There is a strong demand for technological innovations as a remedy for ecological destruction and as pathway to poverty eradication. The predominant belief in technological progress is held up through technicians as well as a society wishing for easy technological solutions for complex ecological and social problems (Pongratz and Baier 2015). Taking this into account, this paper outlines the Blue Engineering Course design that promotes socially and ecologically responsible engineering through the use of building blocks, i.e. self-contained study elements. One of the core building blocks addresses the development of water supply and how societies have dealt with this issue over the course of human history. Participants of this building block improvise skits how they would deal with a sudden water pollution with yet an unidentified cause in six different centuries. This helps to facilitate a discussion about society-nature relations as well as power relations.

**I Blue Engineering Course at Technische Universität Berlin**

This course is the result of a student-driven initiative at Technische Universität Berlin that formed in 2009 (Baier 2013). The very idea that a group of students engages in the creation of a meaningful course not only underlines the shift from teaching to learning, but it shows how seriously this shift can be done. Over the course of four semesters, this student group has developed a course design that disregards any teacher-centered form of education. Instead they have enforced a student-centered approach, so that engineering students acquire the competences to unveil the complex interdependency of their social, political, ecological and economic surroundings. This thorough analysis helps to grasp the personal responsibility as well as the collective responsibility as engineers and humans on micro and macro level (Baier and Pongratz 2013). For the students will also learn to consider the different values, interests and needs within a global perspective as well as within one class(room). The course design encourages democratic decision-making and the corresponding action not only to solve but also to define problems within the course itself and moreover outside of the classroom (Pongratz and Baier 2015).

The first Blue Engineering Course has been conducted by four student-tutors in the winter-semester of 2011/2012 with 25 participants. From the very start it was a course which could be chosen from a list of few possible courses where a certain number of courses from this is compulsory for the master programme of mechanical engineering. This selection of a specific number ‘compulsory’ courses is a widely practiced at German Universities. Therefore the Blue Engineering was credited with 6 ECTS points from the very

beginning. The evaluation and the feedback was overwhelmingly positive so that the student-group offered their course in the next semester as well. This rendered equally positive feedback. Starting from winter-semester 2012/2013 the student-group was granted one lecturer position and two tutor positions in order to ensure a successful further conduction and development of the course.

By now, the course has been conducted 12 times and attracts on average 90 students. 35% of the participants study mechanical engineering and another 35% study industrial engineering where it has been an option of compulsory electives since 2014. The remaining 30% of the participants chose the course as an elective.

Generally speaking, the 14 weeks of a semester are divided into three parts. In the first, tutors conduct a fixed set of building blocks in order to give the participants a concrete idea of what is expected of them later on. In the second part, groups of three to five students conduct already existing building blocks for their fellow students of the course. For this they can choose from list of over 150. In the third part, the students groups conduct a building block which they have developed over the course of the whole semester. The student groups receive continually feedback as well as formative assessment in order to ensure a high quality of the newly developed building blocks.

Building blocks, i.e., self-contained study-elements, are at the core of the Blue Engineering course. They provide clear didactical instructions to facilitate a 60-90 minutes workshop as well as compact, yet multiple perspectives on a complex topic, e.g., ethical codes, recycling, pre-implantation diagnostics, social businesses, gender&diversity, rebound-effect, fracking or cooperatives. Some of these study elements help to thoroughly analyse single technologies while others address social structures and how to change them. Along with the wide variety of topics, every single building block uses a specific set of teaching formats such as case studies, story-telling and station learning. Most building-blocks, however, rely on a specific adaption and new combination of known methods, e.g. learning cascades, advocatus diaboli, triangular method, evaluation sculpture, crime scene investigations and court trials, educational games and challenges. In total, there are now over 150 building blocks (Blue Engineering 2017).

The conduction of an existing building block as well as the conduction and documentation of the newly developed building block are part of the summative assessment. In addition, the students individually keep a learning journal over the whole semester.

The evaluation is presently prepared to be published. For this evaluation, competences that are linked to an education for sustainable development (Haan 2006; 2010) have been adapted as learning outcomes to the specific setting and requirements of the course. They are further designed-down to be used on module level as well as on lesson level (Baier and Meyer 2016). Based on these learning outcomes, a quantitative self-evaluation form has been developed. This self-evaluation of the students takes place at the beginning and at the end of each semester. The results show, that the students perceive themselves as significantly

more competent at the end of course in all tested areas. In addition, there is a qualitative analysis of learning journals taking place that students keep over the course of the semester.

Besides the Blue Engineering Courses at Technische Universität Berlin, there is one course at Technische Universität Hamburg-Harburg since 2012 and one at Hochschule Düsseldorf since summer semester 2016. They are fully conducted by students and student-tutors which even more underlines the student-driven and student-centered approach of the Blue Engineering initiative.

## **II Building Block "Technology as Panacea!?"**

The participants of this hands-on session will participate in a building block that presents how (wo)men have dealt with a sudden pollution of drinking water in different ages of mankind. The building block is called "Technology as Panacea!?" and is a core building block that is conducted each semester. It has been conducted now over 30 times within the course as well as at various (international) workshops to discuss the historic development of technology and its impact on nature and society.

The participants are divided into six groups and each must solve the same problem of sudden drinking water contamination but in another human age, i.e. Stone Age, Roman Empire (Lang and Svenshon 2015) (Schneider 2015), Middle Ages, Industrialization (Wieland 2015), Present (Dinçkal 2015) and Future. The groups must then depict their solutions through small skits. After each skit there is a short discussion and at the end there is a concluding discussion that aims at pointing out the commonalities and differences between the centuries.

This building block helps to realise that technology increasingly becomes a future cause for possible contaminations of water and nature while creating congruent solutions. Thus, the participants realise how society is shaping technology and how technology is shaped through society in return. This includes notably the spatial and temporal effects of technology. In addition, the participants realize that contamination of water is not something that has happened a long time ago or that will happen in the far future, but that it is happening today even within western states (Carson 2002). Overall, this leads to a deep discussion about society-nature relations (Swyngedouw 2004) and power relations (Swyngedouw, Kaika, and Castro 2002) with respect to water but also within our present society in general (Engels and Schenk 2015). People generally are very touched by the building block for through the theater-play they gain more insights as this is a non-traditional form of learning.

Points for the concluding discussion are:

- What are possible causes for the water pollution? In the Stone Age it's mostly natural, biological, geographical causes, (wo)men have little influence - this increases constantly over the ages - technology will eventually become a major cause
- What role did the causes play in the presentation? The participants usually focus on the solutions - totally neglecting the causes

- Water as a most basic need of (wo)men - Participants often don't realize/show in their presentations that water is necessary not only for human life, but for all life
- How is water distributed? Who controls the access to water? - Commodification of water in the present, access to water as a "weak" human right, water as a common good
- How to decide water issues? Water and power relations, water and democracy
- Who is affected by the water pollution? In Stone Age the whole nomadic group, in the Middle Ages and Present Age people are differently affected, since certain people have the resources to find their individual solution
- Advancing centralisation of water pumps - there are three central spots for the water supply of Berlin
- Have social solutions been considered? Many times they are totally ignored.
- What are the common points of the found solutions in all ages? Mechanical Filtration, Cooking, Biological/Chemical Treatment, Import of Water, Exodus to another area (in the future scenario even leaving to another planet)...
- What are actual water pollutions which happened in the last decades? Is it a problem elsewhere/outside of Europe? No, pesticides, aluminum production, nuclear power plants, hormones, antidepressants, pain killers

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# **Engineering Conferences - An Innovative Course for Master Students in Engineering**

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## **ABSTRACT**

A course called "Engineering Conferences" is presented that the authors have developed and installed as a mandatory part of the curriculum in Master programs for engineering students. The idea is to go beyond teaching the standards of academic writing and skills for working with scientific publications. By using a learner-centered approach, we get the students engaged in typical activities around an active attendance of a real conference. They write a paper complying with common academic standards, submit the paper and review submissions of their fellow students. Students also produce a poster and have to defend it in a poster session held publicly on campus. In this article, we present our rationale to develop the course and our results from the first semester teaching this course. This includes the presentation of useful resources for teaching and organizing scientific publishing as well as our reflected learning experience regarding the student's understanding of significance for scientific publishing.

*Keywords* - active learning, challenge based learning, liminal space

## **I INTRODUCTION & CONTEXT**

When developing the curricula for three new master courses in engineering it was decided to include an introduction of students to publication of research in general and particularly to the world of engineering conferences. It was clear from the beginning, that this course should go beyond the kind of skill training which deals with limited details of the publication process in a classroom and leaves out the fun part: the rewarding conference event. With this in mind, the new course was called "Engineering Conferences". On the way to a suitable course concept, the following limitations had to be taken into account: Students admitted to the master course are a heterogeneous group with respect to their Bachelor degrees, their nationalities and their experience with scientific research. Furthermore, resources of the faculty are limited, i.e. an annual real conference with an open call for papers cannot be organized and a participation in an existing conference can neither be guaranteed nor sponsored for every student.

Starting from these initial considerations, we set out to examine five different aspects of teaching and learning as applied to publication of research and developing scientific communication skills.

### **Aspect #1: Undergraduate conference concepts and research journals**

The opportunity for publication of research at an undergraduate level exists for a long time, especially in English speaking countries. The National Conference on Undergraduate Research (NCUR) has been running in the United States of America since 1987 and has been copied by numerous other countries, such as the British Conference on Undergraduate Research (BCUR). The latter is held annually since 2011 and has been surveyed in a study among 90 student participants across three years by (Walkington *et al.* 2016). In the same way, quality controlled publication of research is possible for students by submitting their work to undergraduate research journals, which are also available from institutional to international levels. These approaches have at least four features in common, namely: The organization and review-process is similar to professional conferences and journals, the orientation is multi-disciplinary, the event or process is fully run by students and the latter act on a voluntary basis as author and/or organizer.



The last point implies a natural selection process, which distinguishes the participants from the average student in an undergraduate course, where not everybody can be excellent or motivated by good example. However, with our course, we aim for no less than a better communication culture between professionals across disciplines and social divides. To achieve this, we expose all our master students to the basic standards of peer-reviewed research and provide the opportunity to present their own work on a conference-like level.

### **Aspect #2: Existing publishing resources and related courses for undergraduate students**

At an institutional level, various approaches to learn and train the written and oral presentation of scientific work can be found. Commonly, the required skills of students are developed throughout continuous assignments to write lab reports, project documentations and, finally, the Bachelor thesis. Ideally, the student develops his own style and skills with respect to authorship by learning from various staff members, but the learning process itself and its result or success is rarely made explicit or guided. Exceptions presented by those with disciplinary knowledge are both available and inspiring, see e.g. (Dirrigl & Noe 2014). However, ambitious and valuable courses like “Writing your thesis” or “Presentations for engineers” are often offered on a voluntary basis and outside the faculty, see e.g. (Leydens & Olds 2007, Neilson 2013). This can convey misleading messages with respect to developing a self-confident authorship: “Writing is only an add-on for the best” (they usually book the course first) and/or “I am doing this only to get rid of my defects, but it has nothing to do with my professional development as an engineer”. This situation has been observed and evaluated by (Durfee *et al.* 2011), who consequently developed a writing-enriched curriculum from within the faculty at the University of Minnesota.

For the development of our own approach, we argue that the emergence of scientific communication skills should not only be an explicit and integral part of the curriculum but must be developed as a competence from within the faculty.

### **Aspect #3: Relation of (disciplinary) research and teaching in general and with respect to undergraduate education**

While research and teaching have at least co-existed if not cross-fertilized each other for centuries, it has been suggested and surveyed that there is little statistical evidence for a correlation between the two (Hattie & Marsh 1996). The perception of the relationship between research and teaching is dependent on the current orientation of the institution(s) as well as the history of universities and is thus changing with time (Brew 2006). It can therefore be argued, that the increased awareness for competences based learning outcomes in the development of curricula, as opposed to technical knowledge production, has spread the idea to design research-oriented undergraduate courses, see e.g. (Healey *et al.* 2014) or instruction – despite earlier perceptions of the relation of research and teaching. The move is both not new and natural: While looking for more complex, interdisciplinary challenges, which can be dealt with by groups or students and which are at least partly related to their field of study, teachers and students may find themselves simulating if not carrying out research. While the value and the judgement of research quality in general is currently challenged by governmental influence to develop high-level research in selected universities, see Jenkins & Healey 2010), it may be helpful to remember the medieval meaning of the word “research”. It remains the act to “go about seeking”, see (Merriam Webster Inc., n.d.), and there is no shortcut for students from being involved in this activity to become self-reliant learners. At the latest, students gain some sort of this experience during their Bachelor thesis, which therefore can be regarded as research in their field of study – regardless of quality and outcome. In a nutshell, research is learning, and learning is research and should be supported by teaching.

Thus we regard the Bachelor thesis of each student as an existing piece of research and take it as a starting point for our course module on scientific publishing. According to (Healey & Jenkins 2009), our concept follows a research-based approach. This means it is more focused on the research process rather than on the

research content – which has already been dealt with during the thesis – and it addresses students as participants rather than an audience.

#### **Aspect #4: Active learning in engineering education**

From the above paragraphs it can be concluded that personal engagement in research is an activity allowing students and university staff to meet as learners. However, active learning in higher education can appear in a lot of different forms other than carrying out research and has seen a strong increase in related publications since the turn of the millennium (Lima *et al.* 2017). Consequently, the number of available tools and resources is vast, calling for guides which map and/or navigate through current best practice, see e.g. (Eddy *et al.* 2015). Some of the concepts are often mentioned in the same breath as active learning such as the flipped classroom, and problem or project based learning (PBL). The appreciation of active learning is influenced by the personal learning biography as well as by what we currently know about how learning works in general. A sketch of the philosophical and pedagogical underpinnings of active learning in engineering education is drawn by (Christie & de Graaff 2016), while others have delivered ample proof for the effectiveness of active learning, see e.g. (Prince 2004).

For our own course, the aspect of active learning led to the following conclusion: Participation in an engineering conference requires that the author actively prepares, revises and presents her/his paper or poster. When implementing this as a goal for a master course, the publication process becomes a project with the author as the manager of her/his success, thus placing the responsibility for the associated learning experience into the hand of the student. Despite the overall PBL approach, the supporting course units are also suitable for group exercises and other interactive learning elements.

#### **Aspect #5: The transition phase - from institutionalized learning to learning on the job**

While higher education should generally equip students for their future career, it is particularly apparent for most of those enrolled in a master course that “real life” will start soon. This is no reason for students and teachers to become sentimental, but fertile ground for enhanced learning experiences.

First of all, the way of learning changes anyway: After university, life-long learning becomes much more informal and self-reliant - as it was before school enrollment. The alumna/alumnus will have to change from the consumer of packaged learning goods to the hunter for life-sustaining nutrition, as “experience and education cannot be directly equated to each other” (Dewey 1938). So why not help students *before* leaving university to become self-learners (again)?

Secondly, advancing into new and open terrain may look like trouble ahead but is often the threshold to new advances in learning. This is well described by (Meyer & Land 2005) with the threshold concept of learning, which can ultimately “*lead not only to transformed thought but to a transfiguration of identity and adoption of an extended discourse*”. This transformation can be stimulated by the creation of liminal spaces. (Walkington *et al.* 2016) have shown that undergraduate research conferences are perfect opportunities to open such spaces, helping students to “*reformulate their taken-for-granted frames of meaning by engaging in critical reflection, through a process of dialogue with others. Such dialogue is a central element of transactional communication.*”

Finally, this underlines that advances in learning are often related to advances in communication skills, leading to changes in the perception of identity. This is most obvious in the development phase of a child while acquiring the ability to speak but equally valid for other opportunities where the capability to appropriately express oneself is expanded.

This justifies the preparation of the following challenges for the master students:

1. Implement a course design different to the classical concept of lecture, exercise, lab testing or project etc. The feeling, not to know what to expect, and the experience that engineering-specific

- knowledge is not in the focus pushes students beyond their comfort zone (opens liminal space for new learning experiences).
2. Work with language in new forms: Let students explore the language of the scientific community. Use English as a means of instruction (EMI) with non-native speakers and as the standard in international scientific communication. Expose students to the structure and form of scientific discourse. Introduce them to new tools and means to express her/himself.
  3. Bestow self-authorship upon the learner (facilitates transactional communication for the development of personal and social judgement and responses)

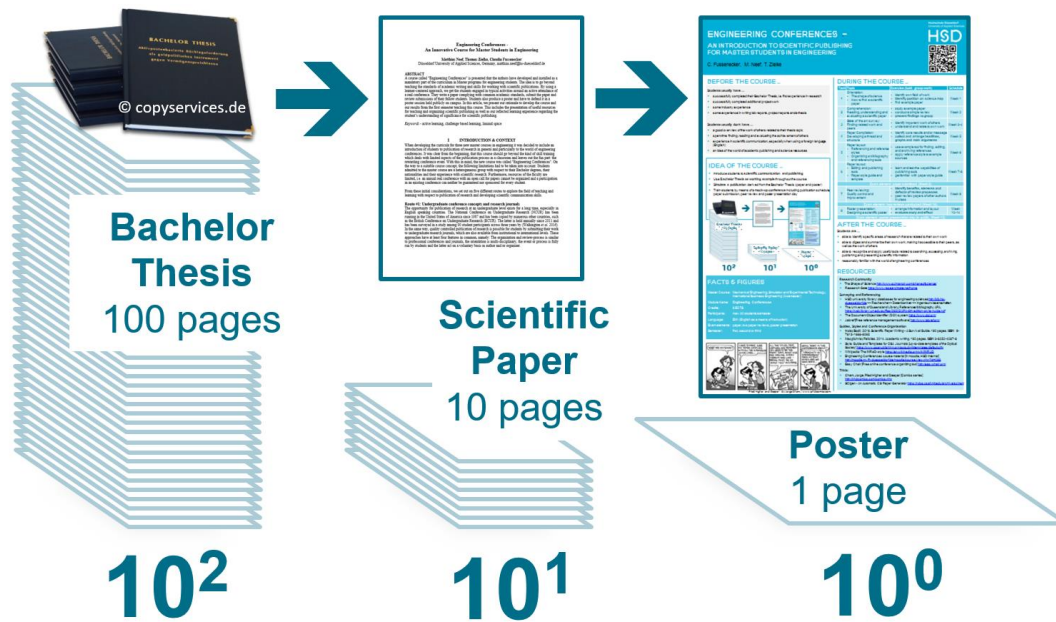
## II COURSE CONCEPT & CONTENT

While preparing for the accreditation of three new master courses, the faculty decided to give the writing and presentation part of the final thesis more emphasis. The module we developed accordingly is designed for 30 master students per semester, while the students are free to enroll to the mandatory course in any of their regular three semesters. Participants are students of a medium sized engineering faculty (approx.. 1500 students) of a University of Applied Sciences in Germany. Since two of the degree courses involved are international programs, we have a share of overseas students, English as a means of instruction (EMI) is set. Six credits can be earned according to the European Credit Transfer Scheme (ECTS). All facts and figures are summarized in Table 1.

With our concept, we aim to address at least some of the seven high-impact educational practices identified by (Kuh 2008). Most obviously, our course meets the need for writing intensive courses, but also underline the value of undergraduate research and includes collaborative assignments. The resulting learning outcomes and the related challenge-based learning opportunities in alignment with the background outlined in the introduction are presented in Table 2. They do not in itself excel beyond state-of-the-art courses in academic writing or scientific publishing. However, the simple approach towards achieving those aims is turned into the following project: You have already earned your first credits with research (bachelor thesis), now prepare to communicate your findings to your peers in the scientific community and go public. Your admission ticket is a research paper and you will be rewarded for your poster (see Figure 1). This cannot be better accomplished than by preparing for an engineering conference. Ideally this would be an exercise involving a real conference, as described by (Watkins *et al.* 2014), for example. For obvious practical reasons, we opted for a simulation of an engineering conference, which exhibits all elements of scientific publishing in a timely order. In more detail, this concept is presented as

**Table 1:** Course details - facts and figures

Module Name	<b>Engineering Conferences</b>
Master Courses	Mechanical Engineering (3 semester) Simulation and Experimental Technology (3 semester) International Business Engineering (3 semester)
Module Type	mandatory
Credits	6 ECTS
Language	EMI (English as a means of instruction)
Exam Elements	paper, two paper reviews, poster presentation
Semester	first, second or third
Number of participants	approx. 30 per semester (60 per year)



**Figure 1:** Reducing page numbers by two orders of magnitude: Evolution of key findings and the core message from thesis to paper to poster

the basic working instructions for the participants:

1. take your bachelor thesis as a starting point
2. re-visit your thesis as research and relate it to research in the relevant scientific community
3. condense, compress and compile the main arguments of the thesis , consider related work, and produce a paper
4. walk through a simulated publication process from abstract over paper submission and peer review to poster presentation in the form of a mock-up conference
5. go public: course finishes with a poster presentation day held in public on campus

Following the storyline of an engineering conference, we identified several tasks to help the students in the process of preparing their research for publication. This also means that we as the teachers are becoming help agents in the publication project with the students managing their own project and learning experience (directing towards a flipped-classroom concept). With reference to the introduction (Aspect #2), it should

**Table 2:** “Engineering conferences” - learning-outcomes and opportunities

Learning Outcomes, directly related to scientific publishing	Related challenge-based learning opportunities
<p>After participation in the course, students are ...</p> <ul style="list-style-type: none"> <li>▪ able to identify specific areas of research that are related to their own work</li> <li>▪ able to recognize and apply useful tools related to searching, accessing, archiving, publishing and presenting scientific information</li> <li>▪ able to digest, evaluate and summarize their own work as well as the work of others</li> <li>▪ able to make their own work accessible to their peers</li> <li>▪ reasonably familiar with the world of engineering conferences</li> </ul>	<ul style="list-style-type: none"> <li>▪ How do I pose a problem precisely?</li> <li>▪ How do I raise and defend a hypothesis supported by facts and arguments?</li> <li>▪ How do I present my main arguments within limited boundaries (space, time, level of interest and knowledge of peers)?</li> <li>▪ How do I relate my work to the work of others?</li> <li>▪ How do I excel in a larger group?</li> </ul>

be highlighted again that we are able to approach the students as researchers and as experts with disciplinary knowledge in engineering on a peer-to-peer level and not solely as instructors for communication skills. It should be noted, however, that at the same time we remain the examination board, which naturally limits the level of student-teacher proximity and which is a distinctive disadvantage over the “real” conference experience.

Each of the tasks on the road to complete a paper and a poster comprises an introduction by the lecturer, followed by one or more exercises (see Table 4). This can be exercises in class or additional homework that has to be prepared for the next sessions. The homework exercises deal with aspects directly related to the preparation and emergence of the final paper serving as supportive suggestions of how the compilation of the paper can be tackled in a useful order. Special care was directed at the design of group work exercises: Students develop content and gain learning experience, with the lecturer standing aside serving as moderator (see exercises in bold face of column 3 in Table 4). As an example for these active learning exercise, the course starts with an “elevator talk” (Annesley 2010): Each student has a few minutes time for preparation and then has to explain the topic of her/his bachelor thesis to another student within two minutes. This exercise is repeated before the students have a chance to reflect their experience. For most of them, it is the first time taking about their thesis topic in English in a very limited amount of time with the clear aim to convey a message (pushed beyond comfort zone).

**Table 4:** Course Outline: Tasks and Exercises

Task	Tasks	Exercise (bold face: group work)	Schedule
1	Orientation: ▪ The shape of science ▪ How to find a scientific paper	▪ <b>“Elevator talk”: my thesis is about ...</b> ▪ identify own field of work ▪ <b>identify position on science map</b> ▪ find example paper	Week 1
2	Comprehension: Reading, understanding and evaluating a scientific paper	▪ study example paper ▪ conduct a simple review ▪ <b>present findings to group</b>	Week 2
3	State-of-the-art survey: Finding related work and peers	▪ identify important work of others ▪ understand and relate to own work	Week 3-4
4	Paper compilation: Developing a thread and structure	▪ identify core results and/or message ▪ <b>collect and arrange headlines, graphs and main arguments</b>	Week 5
5	Paper layout / references: ▪ Referencing and reference styles ▪ Organizing a bibliography and referencing tools	▪ use example tool for finding, editing, and archiving references ▪ apply reference style to example sources	Week 6
6	Paper layout / style: ▪ Editing and publishing tools ▪ Paper style guide and template	▪ learn and test the capabilities of publishing tools ▪ get familiar with paper style guide	Week 7-8
<b>Exam element: paper submitted (Week 8)</b>			
7	Peer-review: Quality control and improvement	▪ <b>identify elements, stakeholder, effects and defects of review processes</b> ▪ peer-papers of other authors in class	Week 9
<b>Exam element: two reviews conducted (Week 10)</b>			
8	Poster presentation: Designing a scientific poster	▪ arrange information and layout ▪ <b>evaluate story and effect</b>	Week 10-14
<b>Exam element: poster presentation day (in public, Week 15)</b>			

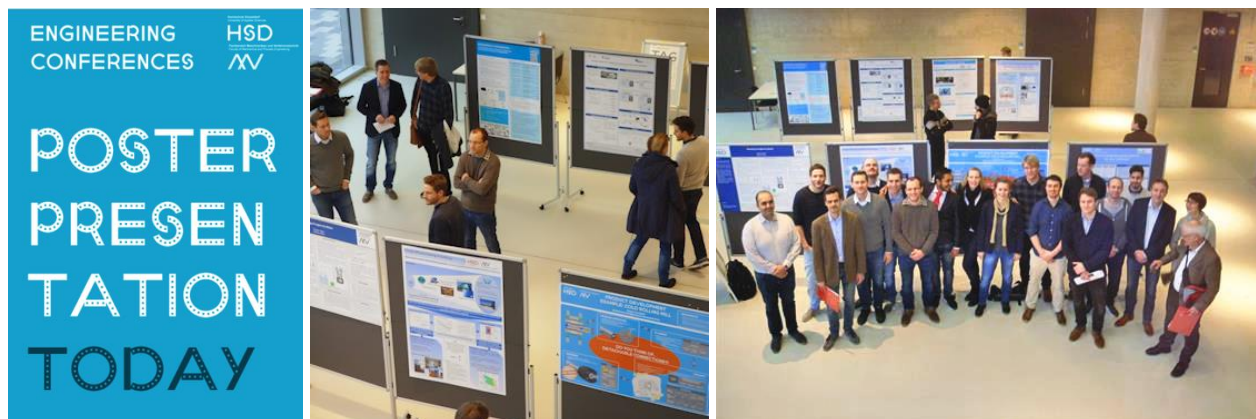
Before the students are asked to re-visit the content of their bachelor thesis, we make sure that they spend a considerable amount of time to orient oneself in the scientific community and to identify and digest related work of others. In many cases this is a new experience for the student: Her/his bachelor thesis may include references to methods described in textbooks or technical articles, but a deep survey of latest international scientific efforts in her/his field of work were not part of the task given to her/him when starting the thesis (for comments on this situation see the conclusions).

As can be seen from Table 4, a lot of emphasis during the first half of the course is directed at the orientation before some formal details of the publication process are introduced. Students are repeatedly encouraged to chew on the summary, main results and thread of their thesis, e.g. by oral short presentation, mindmap of the important figures etc., before molding everything into a given (real) paper template.

To model the paper submission and review process, we use the free web-based conference management system EasyChair ([easychair.org](http://easychair.org)), which allows us to set deadlines, upload papers, define roles such as authors, reviewers and chairs, organize reviews etc. This is not only easy to use for teachers and students but also a real conference standard. After the paper submission, students are requested to conduct two reviews of their peers in class. This includes filling out a review form, which requires to state a reason for each rating and also the upload of the reviewed paper with the reviewer's annotations. If nothing else, the latter is an important and visual verification of the engagement of the reviewer with the papers. In real life, reviewers are volunteers, highly motivated, and usually concerned about their scientific reputation. For the student reviewers, we have not yet found an optimal incentive being both highly effective and practicable for our course.

The last part of the course is dedicated to the preparation of the poster. The poster presentation day is the final event of the course and takes place in the main entrance hall of the faculty building (see Figure 2). While each student has to deliver a two-minutes keynote on his/her research topic, the others are free to browse the final product of their peers or to answer questions of visiting faculty members and students. Both poster and keynote are assessed on the spot by the lecturers resulting in the final grade for the course.

A few results from the 1st semester of the course with 36 participants give an indication of the examination process: The submitted papers were rated by the students (two reviews per paper) including the following aspects: originality and significance; technical soundness, clarity, structure and length, language and writing, figures, references. The average rating across all these categories was 86%. Additionally, the reviewers had to give an overall rating, which yielded an average of 80%.



**Figure 2:** Impressions from the poster presentation day

Credits for the course were earned by the poster presentation, rated by the teachers. The evaluation was based on the performance in the following categories: header, main message & idea, figures & tables, conclusions, references, layout & structure for the poster plus message & delivery for the oral presentation. The average rating was 92%. The good quality of the presented posters supports the idea to qualify, select and sponsor students for a real conference participation as an additional benefit from the course.

### III EXPERIENCE & REFLECTION

With the experience from the design and the completion of the first course semester, we revisit the aspects we examined in the introduction for reflection.

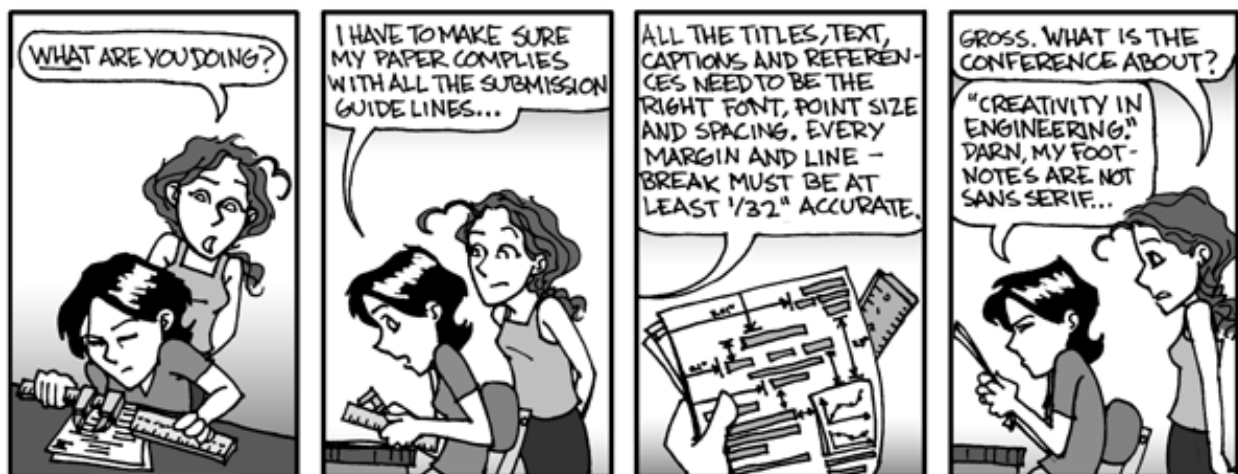
#### Adaptation of undergraduate conference concept

We succeeded in organising and applying the conference concept in the form of a paper submission and poster presentation as a compulsory master course module for 30 students in an engineering master's degree. The setting provided both an underlying story for the project of producing a research publication as well as an open space to present the results outside the classroom. During the course, we observed a significant increase of activity among both faculty staff and students in social networks for researchers and scientists. This positive side effect of the course was boosted by the final event of the poster presentations which vividly enhanced scientific and informal exchange within the home faculty and its neighbouring faculty. It now stands as one of the rare events in the curriculum where the result of learning is proudly made visible outside the classroom. Students were very positive about this culminating event, providing personal satisfaction and success beyond good exam results, despite the effort required to earn credits (see Figure 3).

However, we are well aware of the limitations of our mock-up concept – the real conference remains the ultimate experience: Voluntary participation and a rigorous selection process are key drivers to self-motivation and “one-off” experience. Additionally, the conference location outside the home institution is virtually promoting the step beyond a threshold out into the open and unknown, yet protected learning space filled with enthusiastic peers.

#### Appreciation of scientific writing resources

While preparing the material for the various tasks, we were both overwhelmed and positively stimulated by the vast resources available on scientific writing practices and research communication. As an example, we



**Figure 3:** Creativity in Engineering ("Piled Higher and Deeper" by Jorge Cham /www.phdcomics.com)



explicitly want to highlight two sources that have already appeared to be useful to a large community: Firstly, the survival guide on paper writing by (Holst 2015), salted with worldly-wise glimpses behind the scene and peppered with sketches by Jorge Cham, the maker of PhDcomics.com. Secondly, the compilation of the reference style required by the American Psychological Association (APA), provided by (University of Queensland Library 2013). It provides a precise answer, including examples, to the question of how to cite virtually anything. For those curious and interested in more, we list a number of keywords, loosely arranged in the order of increased caution required when employed in class: DOI.org, IMRaD-Style, JabRef, Shape of Science, ResearchGate, PhDcomics, SciGen, SciHub.

It becomes clear from the above paragraph that we as teachers, while preparing the course, had naturally embarked on the course for ourselves which we claimed as a task for the faculty (as opposed to centralized institutions) in the introduction, namely to develop the emergence of scientific communication skills. We had become inspired enthusiastic learners, fuelling each other with new ideas, searching for more.

### **Agglomeration of research, learning and teaching**

Eventually, we found ourselves doing research in teaching methods and scientific communication, resulting in a recursive learning – research – teaching experience. How did this work out for our students?

When working on the state-of-the art, several students openly expressed, what we had expected from browsing their thesis reference list: “Had I known this before ...” When compiling a thesis, searching for similar work of others is only one feature of research, which may – in some cases – be skipped altogether due to time constraints and the many other new things to tackle (understanding of the problem, application of tools, writing the longest peace of text ever produced so far etc.). This still means the student can obtain a good result in solving the engineering project set out before her/him and why should she/he not repeat (i.e. research) the same thing for the hundredth time again in order to get some exercise? However, not being able to receive the impulses of others and to reflect one’s own results back to those findings strips the student of a vital skill in terms of communication with their peers. This was most openly revealed by one student who, after several iterations of looking for corresponding work in her field, wanted to give up: “I do not find anything”. This could only mean two things: She was still not in the position to apply appropriate criteria to her search or her thesis was a strong candidate for the Nobel Prize. We realized, therefore, that students do not naturally accept their role as researcher despite its closeness to being a learner.

The student’s role as a researcher surfaced again when we became aware that many students initially viewed the course as having little to do with their future job in industry. This can partly be blamed on the way we introduced the course, where we tried to tell how great it was to visit a real conference. This may have produced some frustration as students realized that most of them would probably never visit a real engineering conference. The question “Do I need research skills in working life?” (Murtonen *et al.* 2008) has to be addressed early in the course. This we will definitely change in our next run, conveying the message “you can do it” and trying to highlight how much enhanced communication is vital even for engineers. What we cannot immediately change is the effect of a widespread exam- and content-focussed culture of learning, which is counteractive to the appreciation and positive experience of liminal space.

### **Application of active learning**

From the beginning the students were pushed out into the open and exposed to active learning experiences such as group activity and, overall, to master their publication process as their own project. However, some sense of unease was noticed, whenever the results of a classroom session could not be measured in minutes spent for the consumption of information, i.e. when the students were responsible for producing their own learning outcome.

Not only the students had to grasp the changes in the learning process. Whenever free from transmitting information from the front, it was a privilege to watch students in the process of building skills to overcome barriers and to express oneself. The most prominent example of the development of self-authorship started



with the confession of a student, who was reluctant to revisit her bachelor thesis. It appeared she had been at unease with the topic all along, being very glad that it was all over. We asked her about the topic and together, in a short discussion, we tried to arrange in our minds what she had been doing as her thesis. Weeks later, in a group exercise, she delivered the most precise outline of her thesis using a supportive sketch explaining it all. The breakthrough was at hand, howsoever it had happened.

### **Anticipation of liminal space and life-long learning**

We had thus witnessed at various occasions that troublesome knowledge led to transformed thought and dialogue acted as a central element of transactional communication. This reassured us of our inspiration by the work of others, outlined in the introduction: Such “magic moments” are likely to occur by opening the liminal spaces, which small active learning elements can provide as well as exposure to a conference situation. As the students are near crossing their next threshold when entering working life, we hope to have served them to more readily accept the challenges ahead.

Additionally, we were able to share success (and failure) of our course development and implementation as we were operating as a teaching team. This helped us to increase the variety of challenges for achieving the same learning goals as well as to find different approaches to engage with the students. Not only because Engineering Conferences was our first genuine team teaching experience, we ourselves had entered liminal space and considerably stimulated our life-long learning adventure.

## **IV CONCLUSIONS & OUTLOOK**

A master course module was designed, implemented, and tested with the goal to improve scientific communication skills of engineering students. As the name “Engineering Conferences” suggests, training is based around a mock-up conference, where students have to present the results of their bachelor thesis as a poster. The combination of the following features distinguishes the course concept from similar approaches:

1. It has a storyline (conference preparation) with a public finish (presentation day).
2. It engages the students as researchers, turning the publication of their thesis into a project.
3. It is mandatory for all master students of the faculty.
4. It is delivered by teachers/researchers from within the faculty,  
i.e. from “engineering native speakers”.
5. It can easily be copied and integrated into any STEM curriculum.

For further development of the course, we still see ample room for extension of active learning methods. On a more structural and strategic level, this could lead to placing full responsibility for the organisation of the publication process into the hands of the students. This may require a change in the curriculum for a two-step approach for the student – first semester: participate only, second term: participate and facilitate.

In the future, the course could also serve as an active qualification and selection process for promotional activities of the faculty aiming at an increase in the number of research publications. To start with, we are working towards encouraging and sponsoring the best graduates of our course to participate in a real (undergraduate) engineering conference: The next liminal space waiting to be explored is only a doorstep away.

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# Expert in Teams Course Demands Work on Real Problems

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## ABSTRACT

This paper presents an analysis and a discussion of the didactics of an Expert in Teams course offered at the University of Southern Denmark. In this course, engineering students shall develop their cooperation skills by participating in group work and by studying 1) idea generation/innovation, 2) developing collaboration and 3) development and refinement of a business plan. This study identifies that students often have to “unlearn” attitudes from their earlier studies. This shift in focus seems to generate some resistance to learning and can, to some extent, be demotivational and may hamper transfer of learning from the Expert in Teams course to other settings. To improve students’ English skills, this study also finds that a need exists for more courses in English at earlier semesters.

Supported by literature of acquisition of learning on both the individual level and the group/organizational level, this study identifies that working on real problems forms a solid foundation on which to develop the essential engineering competencies of cooperation.

*Keywords* - Expert in Teams course, real problems, transfer of learning, cooperation

## I INTRODUCTION AND PURPOSE

An important part of the engineering educational program at University of Southern Denmark (SDU) is that students develop competencies of working together in cross-functional teams. The Expert in Teams (EiT) course mixes together BA engineering students in their fifth semester from all different engineering educational backgrounds, and the course is considered a critical foundation to develop teamwork skills in cross-functional teams. In this course, between 400 and 500 students are split into themes in which two teachers teach, guide, and supervise about 40 students. These 40 students are then divided into groups of five to six students. Each individual group is mixed with students from different engineering educational backgrounds and, in most cases, one to two international students are placed in each group. The language taught at the EiT course is English, so because the majority of the engineering education programs at SDU are taught in Danish, some students will be challenged for the first time to study, communicate, write, and complete a final exam in written and oral English.

Students in the EiT course work on a project in which they contribute expert skills from their own educational program. The purpose of course is three-fold: 1) An innovative product or service idea must be developed in each group. 2) Based on this innovation, a business plan must be developed and refined. 3) Participants must reflect on how to develop work within a team setting and on how different collaboration models can be used to support the development of collaboration within a team. All three parameters are evaluated equally. The two teachers connected to each theme do some lecturing, but they primarily act as supervisors.

Prior to taking the EiT course, students have been studying with fellow students from their own educational program. Chemistry engineering students, for example, have not yet studied with students from the mechanical engineering program, the product development and innovation program, or the robotics program, etc. Thus, the EiT course often brings students out of their comfort zone, and the experience results in frustration and dissatisfaction. Some students express that they find the course to be a waste of time or that they simply hate the course.

Due to the common level of student resentment, it is especially challenging for a teacher to make the EiT course successful. However, the development of skills and competencies of how to work together in a project team is found to be important for engineers. More than a decade ago, Mette Buck Jensen (2006) proclaimed in the Danish weekly journal *Ingeniøren* that because 80% of engineers work in project teams, the ability to collaborate and to communicate in project teams is extremely important to become successful in engineering jobs.

Hence, the purpose of this paper is to investigate the following research question: How can real problems and didactical models best support the learning outcome of collaboration among engineering students?

This study is delimited in that it includes only the teachers' reflections on the EiT course. A questionnaire was sent to participating students, but once the course ended, students returned to their home universities all over Europe. Responses to the questionnaire came in at less than five percent and, consequently, were not included in this paper.

## II LITERATURE OF ADULT LEARNING AND TRANSFER

Dimensions of learning. Within the research field of adult learning and lifelong learning, Knud Illeris has developed several frameworks for learning. Figure 1 below illustrates a framework for learning inspired by Illeris (2003); learning takes place within three dimensions: 1) “Meaning/ functionality” which is regarded as cognition, 2) “Sensitivity/mental balance,” which is related to the emotion and the motivation of the individual student, and 3) “Sociality,” which is related to the interaction between the individual student and the group or the organization.

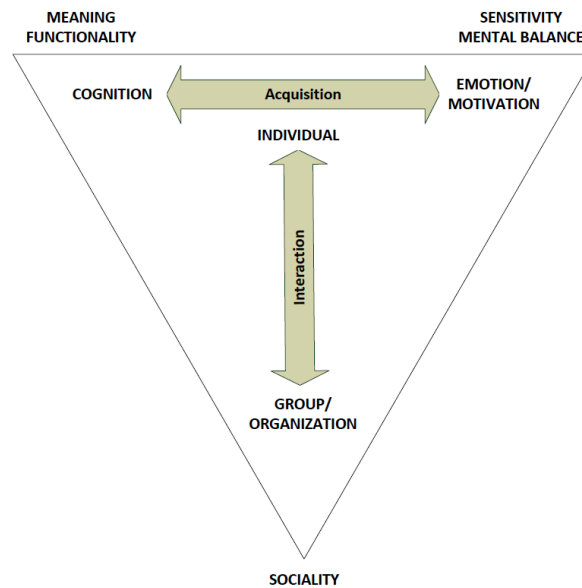


Figure 1. Dimensions of learning (Inspired by Illeris, 2003)

Figure 1 depicts how learning at the individual level (the horizontal level) takes place as a process of “acquisition” between cognition and emotion/motivation. The acquisition process depends on the individual student’s ability to identify meaning of the acquired knowledge and on his/her individual motivation. If the student finds that what has to be learned will give a meaning to him and if the student is motivated, the acquisition of knowledge will be very high. On the other hand, if the motivation is low and the process of cognition is difficult, the learning outcome will also be low.

However, as illustrated on the vertical level in Figure 1, learning always involves others; interaction takes place with others. Figure 1 describes this component as “Sociality.” Illeris (2003) identifies this concept

as in relation to society, but in this study, we focus on learning in the EiT course where group work and collaboration occurs. Figure 1 with regard to the EiT course demonstrates that learning takes place between individuals of a group and the organization, including the whole EiT course of 400-500 students and the individual theme groups of about 40 students. Learning in the EiT course is therefore considered to take place both in context between cognition and emotion/motivation on the individual level and in interactions with other members of the group/organization.

Transfer of learning from the classroom and to practice, as in a real job, has been researched for a number of years. In a very early study, Woodworth and Thorndike (1901) identified that if the learner experiences similar elements, the transfer of learning can be improved. The transfer of learning is particularly vital in the professional career paths of nurses, clinical doctors, teachers, and lawyers (Wahlgren and Aarkrog, 2012). Because 80% of engineers are expected to work in project teams, the ability to collaborate and to communicate is therefore extremely important (Jensen, 2006). The transfer of learning with regard to collaboration skills from the EiT course may therefore be important for engineers.

Transfer factors, unlearning, and the paradox in learning. Although it sounds logical, Wahlgren and Aarkrog (2012) demonstrated that, in particular, the student needs to be motivated towards what has to be learned. If students understand the goals and recognize the need for those skills, it will be easier for those students to transfer what has been learned into a new context. Metacognition is described as the ability for the student to understand that what is learned in practice is relevant to future situations. Accordingly, metacognition improves the transfer of learning (Wahlgren and Aarkrog, 2012). Further, Wahlgren and Aarkrog (2012) identified a paradox in the transfer of learning which calls for unlearning. When students attend a course, they want to learn new ideas and try new experiences. On the other hand, students also want to be safe and confident and to develop their habits and routines. Some individuals find it easy to be involved in a change process whereas others find it difficult. Wahlgren and Aarkrog (2012) determined that while students do seek new knowledge, they do not want to learn so much that they act differently. However, if the identity of the student is threatened, resistance to learning will occur. Students who are more experienced may face a need for more unlearning and demonstrate a higher resistance towards learning.

Wahlgren and Aarkrog (2012) state that overdoing learning, coaching, and supervision may create a foundation on which students become able to master the subject and improve their transfer of learning. The right climate for transfer and follow-up on what has been learned are essential elements in improving transfer of learning (Wahlgren and Aarkrog, 2012).

### **III WIND TURBINE BLADES - PROBLEMS - INVOLVEMENT OF EXTERNALS**

This paper discusses the involvement of real problems from an external company researched during a particular EiT course which involved 38 students. In this section the involvement and flow of learning and issues related to this particular EiT course will be described from the teacher's perspective. Later, in Section IV, learning issues and transfer of learning will be discussed in relation to theory, and conclusions drawn in Section V.

The wind power sector has rapidly expanded in the northern part of Europe. For several decades, wind turbine manufacturers have developed and released new and larger wind turbines every 1-2 years. Made of composite materials, blades have consistently become longer, lighter, and optimized for efficiency. However, offshore wind power installations are subject to heavy changes in loads due to flap-wise and edge-wise bending, gravitational loads, torsion loads, axial loads, and pitch deceleration and acceleration (Katman et al., 2015). With problems from storms, lightning and heavy weather conditions, the manufacturers and operators of offshore wind turbines have identified a number of problems that impact the blades, including leading edge erosion, cracks in gelcoats, core failures, debonding, and delamination (Katman et al., 2015). Based on a literature study, the EiT teachers conducted a presentation of these problems, and a week later engineers from a leading European operator of onshore and offshore wind

installations exemplified blade problems at the EiT course. After these presentations and their own studies, students were expected to study these issues, develop solutions through innovation, create a business plan, and improve their collaboration skills through this study.

Students expressed that they found the presented issues exciting and that they thought the issues fit well with the group's diverse engineering backgrounds. They discovered that within their group, they were able to look at the same issues from very different engineering perspectives (from robotics, physics, chemistry, manufacturing, product development, innovation and global management, manufacturing and other engineering study programs). Other students felt that the presented problems were confusing to work on. Remarks made by more than one student were *"The engineers from the company just presented their problems but did not give us any tasks"* and *"Normally our teachers present a task and we solve the task."* However, at the end of the course and at the final exam a number of students explained that the presented problems constituted an excellent foundation for their group work. Some students explained that in other cases their colleagues participating in other themes of the EiT course had suffered from too simple tasks and did not have enough room to establish a solid base for a diverse group work.

Table 1 below illustrates the main process of steps presented during the EiT course. In particular, three issues were found important to consider.

Table 1. Main steps during the EiT course

Week	1	2	3	4	5	6	7	8	9	10	11	12-15	16
	Intro. Formation of groups. Intro to problems.		Presentation of problem by involved company. Presentation of tools for collaboration.		Some students express heavy resistance to work on collaboration and to create a business plan.	Teachers supervise. Short business plan lecturing. Main phase of students' work.					Students present work for involved company. Feedback from peer students, teachers, and involved company.		Exam

The first minor issue was the establishment of groups from diverse educational backgrounds. Inspired from studies by Ravn (2007), students were asked to present themselves to someone they did not know, then each half minute the teacher announced to "change partner" and to repeat their presentation. Finally, each student filled out a post-it with his information, and the groups were formulated and visualized on a large paper sheet. This method proved to be an appropriate way to categorize the groups.

A second issue was that after the presentations from teachers and the involved company, students had to convert problems and develop these into something that they were able to study and work on.

A third major issue was that some 10-20% of the students, one-third of the way into the course, expressed negative attitudes towards working on the purpose of the EiT course; they did not find it relevant to work on the tools for collaboration and on creating a business plan. Instead, they wanted to focus more on the engineering tasks. In this case, the teacher found that he was under extreme pressure as a result of the negative attitudes from a significant percentage of the students. Ironically, their very resistance speaks volumes to their need to develop collaborative skills.

## IV DISCUSSION

The development of collaboration skills among engineering students requires working on problems that call for diverse engineering skills instead of working on solving tasks given by the teacher. At the final exam for the EiT course, "real world" problems were cited by almost all students as important material. Cases from industry support student learning because different engineering perspectives contribute to a solution.

As shown in the learning triangle (Figure 1), inspired by Illeris (2003), learning on the individual level takes place as a process of acquisition between cognition and emotion/motivation. Within the engineering

domain, the tendency is to focus on cognition when a number of technical aspects must be learned. Most students explained that they were accustomed to solving tasks provided by the teacher; they were not as comfortable being asked to craft their own problem statements and solutions. Woodworth and Thorndike's early (1901) study establishes that if humans are given the opportunity to transfer learning to a similar setting, it is relatively easy to improve learning and to transfer that knowledge to a new setting. However, when students are in a course like EiT and are asked to work on problems and new perspectives, then motivation can be challenging. As Figure 1 shows, the acquisition of learning on individual level can be influenced. Figure 1 also portrays that the interaction within a group is important to facilitate a learning process; hence, the EiT course will be an important part when students must develop their collaboration skills in order to meet the requirements for participation in projects in future jobs.

Because 80% of engineers work collectively on projects the competencies of collaboration and communication are extremely important (Jensen, 2006). The EiT course and the purpose of collaboration may therefore be an important course to develop students' abilities to collaborate in cross-functional teams. However, one pedagogical element that must be considered is whether this course takes place too late in the engineering educational program. EiT occurs during students' fifth semester, and EiT teachers often experience a need for unlearning, negative attitudes, and resistance towards this course. According to Wahlgren and Aarkrog (2012), too much resistance towards learning hampers transfer of learning to a new setting. One potential solution is that a minor version of the EiT course might be offered during an earlier semester.

Students in the EiT course are frequently removed from their comfort zone. Some students have to read, write, communicate, and to take their final oral exam in English for the first time. Some students have to study together with international students for the first time. In many cases, students must give up their previous knowledge and attitudes as students from other engineering programs bring in new perspectives and may question learning gathered from four earlier semesters. Wahlgren & Aarkrog (2012) finds this to constitute a paradox in learning; most students want to learn something new—but not too much. The learning triangle in Figure 1 clearly illustrates the student's issues during the EiT course, including how the individual student in his acquisition constantly alternates between the cognitive process and his emotions/motivations. A major issue is that if too many changes are expected for an individual student, then student's resistance to learning may be too high and this serves as a barrier to the cognitive process. This course demonstrates that there may be a need for English-only courses at earlier semesters to avoid challenges related to too many parameters at the course.

The involvement of real problems presented by employees from an external company supported by elements from research seems to constitute a solid foundation when students from very different educational programs have to study and develop skills of innovation, business plans, and collaboration. It seems to be important to work on problems and not on tasks; problems give much more robust perspectives where students can choose their own focus, which fits the skills needed within the group.

## **V CONCLUSION AND FURTHER RESEARCH**

The purpose of this study has been to study how real problems and didactical models can support the learning outcome of collaboration among engineering students.

The study concludes that a course like the EiT course at the University of Southern Denmark constitutes an important part of a learning program to become an engineer of the future, where engineers are expected to collaborate in cross-functional project teams.

The introduction of real problems – and not on tasks – creates a solid foundation on which students are able to develop their study in a number of different directions; that diversity enhances the specific groups gathered together from different engineering educational programs.

The didactical model illustrated in Figure 1 constitutes an important model for the teacher's preparation and for discussion with students about how to improve collaborative learning. The model shows its particular relevance to support both teachers' and students' considerations of cognition vs.



motivation/demotivation on the individual level of learning and to support learning through interaction between the individual student and the group or team in which learning occurs.

This study also identified that students in the EiT course most often have to unlearn attitudes they have previously learned. This awareness seems to create resistance to learning and can, to some extent, be demotivating; it can, in fact, hamper transfer of learning from the EiT course to other settings in some cases. However, when engineering students have to develop competencies of collaboration the development of a minor EiT course may be needed during an earlier semester. There may also be a need for students at earlier semesters to study courses in English and in that way to become more comfortable developing their English skills earlier.

This study is based only on the teacher's reflection of an EiT course. A more in-depth study is planned for a future semester; an examination of the whole timeline of the EiT course from the beginning of the course to the final exam will occur. In such a study, the students' motivation, tasks vs. problems, learning about collaboration, knowledge of business plans, and comfort level with English will be investigated further.

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# Experts in Teams – An experiential learning method

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## ABSTRACT

This study discusses the pedagogical characteristics of the hands-on interdisciplinary innovation course Experts in Teams (EiT) of the University of Southern Denmark (SDU).

EiT is a 10 ECTS course mandatory to all fifth semester students on any engineering program at the Technical Faculty of SDU. Course duration is 12 weeks with two weekly sessions of which only one is teacher controlled. In 2016 EiT involved approximately 425 students, 22 teaching resources, and 6 companies. These numbers will increase in the years to come.

Traditionally we distinguish between practical courses and theoretical courses. Most of the practical courses are group work along the lines of project based learning. EiT is in a way both. It is a practical course in as much as our students get hands-on experience with interdisciplinary team work and innovation processes. EiT is a theoretical course in as much as our students are taught various tools that aid and guide them in the innovation process and in the interdisciplinary team work.

The theoretical foundations of EiT viewed as a teaching method is experiential learning and its derivative project based learning. In the beginning of the 12 weeks course period EiT is taught much like a traditional theoretical course. After only a few weeks this all changes and the teachers become facilitators of the students' own learning which is relevance-steered by the innovation project at hand. These characteristics are typical for experiential learning and in this way EiT becomes a learning method rather than a teaching method.

Besides discussing the pedagogical characteristics of EiT, the study also gives a general introduction to EiT as it was taught at SDU fall 2016 as well as a brief review of the basic theory behind experiential learning. As such this study serves both as an introduction to e.g. new teachers of EiT but also as a starting point for a clarification of the features that makes EiT an experiential learning endeavor.

*Keywords* - hands-on innovation teaching, interdisciplinarity, teaching method, learning method, experiential learning, project-based learning, Kolb's learning theory

## I INTRODUCTION AND MOTIVATION

In 2001 a new course named “Eksperter i team” or in English “Experts in Teams” (EiT) was launched at NTNU in Bergen (Sortland, 2015) (NTNU, 2016). Since then several other universities in Scandinavia have installed similar courses – all inspired by the NTNU course.

At the Technical Faculty (TEK) of the University of Southern Denmark (SDU) EiT was launched in 2006. EiT is mandatory for all students of TEK, i.e. all SDU engineering students and is placed on their fifth semester. For students from other faculties the course is an elective. Our students work in interdisciplinary and preferably cross-cultural<sup>1</sup> teams on an innovation process (or at least parts of it). The course is very hands-on and learning-by-doing and it is so in a student-directed way with little lecturing and only a small

<sup>1</sup> Here I take ‘cross-cultural’ to mean ‘international’ (more or less).

amount of prescribed literature. Essentially EiT at TEK/SDU is very similar to EiT at NTNU though at TEK/SDU we emphasize a bit more the innovation part of the course at the expense of the facilitation part (more on this later on).

At TEK/SDU EiT is a consequence of the “The Engineering Education Model of the University of Southern Denmark” (DSMI) - an education model that goes for all engineering programs at TEK/SDU<sup>2</sup>. Among the drivers for DSMI is a perceived demand from society to turn to good account the many hours our students spend at obtaining their diplomas by endowing our students with employability skills and competences of a more general character.

Obviously EiT at TEK/SDU is not a conventional university course. The features described above set it apart from the traditional teacher directed university courses with a well-defined course curriculum and course syllabus. The question as to what kind of teaching method EiT is naturally arises. The answer, I suggest, is that EiT is an experiential learning method.

In the following I will try to describe in more detail the characteristics of EiT as a teaching and learning activity. At the same time I will highlight important elements of the organization of EiT at TEK/SDU. Knowledge of experiential learning theory is required in order to appreciate the experiential dimension of EiT. Therefore I will start out by giving a very brief introduction or brush up to this topic. After the introduction of the theoretical framework I turn to the practical aspects of EiT as it is implemented at TEK/SDU. Finally I discuss the characteristics of EiT that identifies it as an experiential learning course.

## **II EXPERIENTIAL LEARNING**

### **Introduction**

It comes as no surprise that EiT fits the characteristics of a project-based learning (PBL) method well – after all PBL is mentioned in DSMI. Somewhat less trivial is the notion of EiT relying on experiential learning to achieve the learning outcomes. What exactly does this entail? What are the foundations of experiential learning? And what is e.g. the difference between experiential learning and PBL?

### **Kolb’s experiential learning theory**

Back in the 1970s Kolb and Fry developed the basics of what is now known as the experiential learning model (Kolb & Fry, 1975) (Kolb, 1984). The model is typically illustrated as shown in Figure 1 (Chapman, 2013) where the black boxes represent stages in the learning cycle, the red boxes are associated learning styles, the blue box with arrows represent a processing continuum (doing or watching), and finally the green box with arrows represent a perception continuum (feeling or thinking).

Learning is seen as a continuous process where individuals are actively involved in new experiences, reflect on what has taken place, theorize about the experience, and finally apply this knowledge to new situations (Kolb, 1984). Kolb focuses on the process of learning and not on the concrete learning outcomes and talks about knowledge as created through the transformation of experience.

<sup>2</sup> In the following I will consider only the TEK study programs of campus Odense. TEK/SDU has a campus also in Sønderborg where the students of course also have EiT. EiT Sønderborg is, however, a course separate and different from EiT Odense.

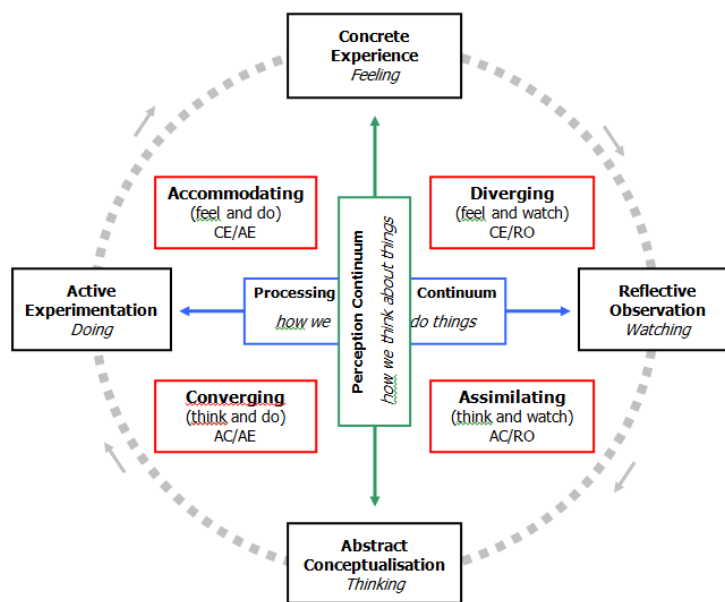


Figure 1: Illustration of Kolb's learning model (Chapman, 2013)

It is beyond the scope of this study to give a full interpretation of Kolb's theory. Here I shall emphasize the two relatively trivial facts that: 1) experiential learning begins and ends with the students active involvement in an "experience" and 2) that deliberate and explicit reflection on the actual outcome of the experience as opposed to the believed outcome prior to the experience is of paramount importance to consolidate new knowledge (Association for Experiential Education, 2007-2017) (Kolb, 1984) (NTNU, 2016).

### Project-based learning

Experiential learning takes many forms (Garlick, 2014). Of particular interest to this study I shall mention *problem*-based learning and *project*-based learning where the latter can be seen as a further development of the former. In the literature both are referred to as PBL-methods.

Problem-based learning is an approach that involves real-life problems and their solution. The focus is not on how to apply certain methods to a given problem – that would be the traditional way to go about it. In problem-based learning the focus is on determining e.g. what methods are appropriate to solve a particular problem – which may well involve self-learning of those methods. Supposedly it therefore develops the skills of reflection, reasoning, and observation as opposed to just being presented to and collecting facts (Garlick, 2014). The problem itself could also be developed or refined by the student.

When the problem takes on a project-like character and starts to consume a substantial amount of time then the problem-based learning becomes project-based-learning. Clearly the scope of a "project" is wider than the scope of a "problem". The "project" may involve several problems and require multiple methods and lots of project-specific knowledge.

PBL, be it problem or project based, are not intrinsic group-work methods, and it is entirely possible to do PBL as an individual activity.

### Learning outcomes and experiential learning

The curriculum is replaced by reflection on the "experience" the student have had during the course (NTNU, 2016, p. 16). Reflections on an "experience" leave ample room for the actual learning outcomes to be very different from student to student and they become subjective in the sense that they depend on

the individual experiences of the students. In general this means that the learning outcomes of the course description of an experiential learning based course will be much less tangible – border lining vague - than the learning outcomes of a traditional curriculum based course.

### **Teacher versus facilitator**

With subjective student dependent learning outcomes clearly also the teacher role of experiential learning must be very different from the teacher role of a curriculum based course. The teacher's role will no longer be that of presenting e.g. theories to the students. Instead the teacher role becomes that of a facilitator. During experiential learning, the facilitator's role is to (Association for Experiential Education, 2007-2017):

- Select suitable “experiences”
- Pose problems, set boundaries, support learners, provide suitable resource, ensure physical and emotional safety, and facilitate the learning process.
- Recognize and encourage spontaneous opportunities for learning, engagement with challenging situations, experimentation (that does not jeopardize the wellbeing of others) and discovery of solutions.
- Help the learner notice the connections between one context and another, between theory and the experience and encouraging this examination repeatedly.

### **Critique of experiential learning**

It should be noted that not everybody agrees that experiential learning is all it claims to be. Apparently research shows that only when a sufficient level of prior knowledge is reached does experiential learning provide a better alternative than the traditional curriculum base courses with guided instruction are almost always superior (Kirschner, et al., 2006).

Besides the more theoretical considerations of the problems with experiential learning, students and professors alike also complain that PBL in general leads to redundant research and non-constructive speculation (Provan, 2011).

## **III EXPERTS IN TEAMS: THE COURSE AND ITS ORGANISATION AT TEK/SDU**

### **Introduction**

The following section describes in some detail the organization of the course EiT at TEK/SDU. The course is deeply rooted in “The Engineering Education Model of the University of Southern Denmark” (DSMI) - an education model that all engineering programs at TEK/SDU adhere to (SDU/TEK, 2015). DSMI is discussed first and then the actual organization of EiT fall 2016 is discussed.

### **DSMI**

The purpose of DSMI is to establish a foundation for the engineering programs at TEK/SDU. It is both a model and a strategy for how to construct an engineering education program. As a strategy it seeks to ascertain that the skills and competencies of the SDU engineers comply with market demand. As a model it outlines the organization and constituent components of an SDU engineering program.

Albeit recognizing the importance of traditional theoretical lecturing courses, the model puts emphasis on active and project based learning. On each of the first 4 semesters of any engineering program at SDU, 10ECTS are reserved for a semester project. In the semester project the students do project based group work on real-life problems. The semester projects let the students work with the theoretical content of the semester in an applied way. On the 5th semester EiT takes the place of the semester project. The students

are put in interdisciplinary groups and asked to work with real-life innovation. There is no overlap, except by coincidence, between the EiT project content and the rest of the courses the students are taught on that semester.

The project based learning approach reflected in DSMI is considered not only to facilitate deeper learning of the semesters' theoretical content but also to strengthen general skills and competences. The following general skills and competences are mentioned in DSMI (SDU/TEK, 2015).

Engineers trained at SDU must have the capacity to:

- Work independently and be able to:
  - Plan strategies for their own learning process
  - Evaluate their own learning process
  - Focus in-depth on technical disciplines
  - Formulate and analyse a problem in a structured manner
- Cooperate and be able to:
  - Work in an interdisciplinary context
  - Work with people from other academic and cultural backgrounds
  - Document and communicate their knowledge and results verbally and in writing to different target groups
  - Evaluate the work of others and give them feedback
  - Work in a project-oriented context and in teams
- Apply their knowledge, skills and competencies in practice and be:
  - Receptive towards new problems and solutions
  - Innovative and creative
  - Solution-oriented

These general skills and competencies are all clearly targeted by the semester projects and EiT in conjunction with EiT covering the interdisciplinary and innovative competencies.

A progression in openness of the semester projects is intended with DSMI. At the first semester the problem of the semester project will thus be fairly closed while it will open up more and more during the following semesters. Clearly this also leads to a progression in student-directedness and on the fourth semester the students may even be responsible for formulating the problem of their semester project and seeking the necessary information to solve it themselves, i.e. on the last semesters the students' work with the semester project comes very close to experiential learning.

The semester projects and EiT are the ECTS points that most obviously target the general skills and competences of DSMI mentioned above. Of course students also work their core subject skills and competencies in the semester projects but in EiT this changes somewhat.

### **Organization of EiT**

EiT at TEK/SDU is a 10ECTS mandatory course for all engineering students at the fifth semester. Exchange students usually visit at their fifth semester and most of them take EiT corresponding to 5-10% of the total number of students on the course. Occasionally also a couple of students from other faculties might choose EiT but they do not constitute any significant group.

The course thus far only runs in the fall – mainly because all engineering programs start after summer. All fifth semester time tables have Wednesdays' and Thursdays' afternoons reserved for EiT from 12.15-15.45. Wednesdays are teacher controlled whereas the students are on their own on Thursdays. The time slot on Thursdays is reserved in the timetables to make certain that students from different programs have opportunity to meet and work together.

The students of EiT at TEK/SDU, counting hundreds, are divided into themes of around but preferably not above 40 students per theme. The themes are introduced to the students on the first day of the course and each student is invited to prioritize 3 themes. The students' preferences determine in which theme they are placed. Of course promotion of interdisciplinarity and cross-cultural group work must also be taken into account. Therefore an ad-hoc maximum on the number of students from the same engineering program in a theme is used. Likewise exchange students are divided equally among the themes. Not all students will therefore be given their first priority theme - but in the order of half the students half will. The rest will be given their second and third priority theme with only a few being given the latter.

In the themes the students are again divided into teams of 5-6 students. Also here interdisciplinarity is ensured by allowing only two students from the same program in each group. Likewise exchange students are distributed evenly among the groups. The groups must be formed in week 2 of the course. There is no central policy on how to form the groups and the teachers can use whatever method they see fit. In some themes it is left for the students to decide for themselves, in some themes the teachers simply decide, and in some themes some other method is preferred. Some students always complain that the group formation process could have been better.

Two teachers are allocated to each theme. They are ultimately responsible for the theme curriculum although the curriculum is being developed in strong collaboration with the EiT coordinator.

### **Examination**

The students hand in a series of deliverables at the end of the course. Together with an individual oral defence and a group presentation those deliverables are evaluated and an individual grade is passed. The deliverables count an individual learning report and 3 group hand-ins: a concept and skills poster, a collaboration poster, and a business report.

### **Learning outcomes**

To walk through the individual learning outcomes of EiT is beyond the scope of this study. It suffices to say that they all target the general skills and competences of DSMI mentioned above which also makes them somewhat intangible and vague. The course description mentions innovation process and interdisciplinary team work to be at the main "experiences" of the course - all very much along the lines of experiential learning as I shall discuss later on.

### **The EiT themes**

Two factors shape our themes:

1. the overall course objective that our students should encounter real work-life innovation processes and
2. the requirement that in the ideation phase of the course all students should be able to bring their core study-program competencies into play.

Since the vast majority of our students are students of engineering the above mentioned factors reduce to (at least) requiring of the themes that they should be engineering relevant, i.e. they should deal with the types of problems that engineers would normally encounter "out there".

We use the two concept pairs *entrepreneurial/intrapreneurial* and *push/pull* to classify our themes. In *entrepreneurial* themes the students work with start-ups, i.e. they qualify their value propositions assuming that they are a start-up company. In *intrapreneurial* themes the students work with innovation within an existing company, i.e. they qualify their value propositions on behalf of the company.

Typically a theme will work with a company in an intrapreneurial setting. The company presents a problem framework within which the students then innovate as if they were a project group in the company.

We also have pure entrepreneurial themes. These themes could reflect one of TEK/SDU's core research areas, e.g. drones. The groups in such a theme work in a push-like entrepreneurial manner with the aim of qualifying an idea and pitch it to investors. Some entrepreneurial themes are not as such thematized. Here the students have freedom to develop and qualify any engineering relevant idea they might come up with, again with the ultimate goal of pitching it to a potential investor.

#### **IV EXPERTS IN TEAMS: AN EXPERIENTIAL LEARNING METHOD**

With the theoretical framework on experiential learning and the description of EiT at TEK/SDU fall 2016 in place we are now ready to identify and highlight the characteristics of EiT – or at least some of them - that makes it an inherent experiential-learning based course.

##### **Characteristic 1: The ideation phase – phase 1 of the innovation process**

As stated above our students are presented with very open problem frameworks and asked to develop and qualify an idea within that framework. They are given tools for ideation but after that they are left on their own to do the actual ideation. They are responsible for providing the information they need on e.g. markets and technology. Nobody but themselves drives the process.

##### **Characteristic 2: The qualification phase– phase 2 of the innovation process**

In this phase the students are also on their own in as much as they are the ones who have to identify in what ways it is relevant to qualify their idea. They are given tools - examples could be budgeting tools or Osterwalder's business model - which they can use in the qualification phase, but it is up to themselves to select and obtain all the data they need for the qualification.

The characteristics of both the ideation phase and the qualification phase distinguish both as Kolbian learning experiences rather than as part of a traditional course curriculum.

##### **Characteristic 3: Reflection on the interdisciplinary team work**

Throughout the course the students are asked to reflect on the interdisciplinary team work. Again they are given tools which can aid them in this but essentially the interdisciplinary-team-work-experience becomes a second Kolbian learning experience.

##### **Characteristic 4: Reflection on own learning**

As part of the examination the students are asked to prepare an individual learning report. In this report they reflect on their own learning. Both general engineering competences and specific core subject competences should be part of the reflection.

##### **Characteristic 5: The role of the teacher**

The teacher instructs the students in the use of various tools, e.g. collaboration- and ideation tools. The structured guidance in the use of such tools is very close to what would be expected in a normal curriculum based course, but the tools themselves are not part of the course curriculum – they serve only as suggested aids in the innovation – or group process. The teacher organizes the actual theme and coordinates with external partners but the teacher has little or no knowledge about the actual project framework and cannot serve as an expert on this. The main role of a teacher on EiT at TEK/SDU is that of a facilitator complying more or less with the facilitator characteristics mentioned above in section 2.



### **Characteristic 6: The learning outcomes**

Albeit the course description is not explicit about EiT being experiential learning the learning outcomes are all very much what one would expect from such a course, i.e. somewhat intangible and vague and mentioning learning content only at a very general level with few if any particulars. In the course description we can identify the two processes of innovation and interdisciplinary collaboration as two “experiences” (cf. characteristics 1 and 2) the students have to analyse and reflect upon. In the end it is their ability to do exactly that, i.e. to analyse and reflect upon those two processes, which is evaluated at the examination.

## **IV CONCLUSIONS**

The course Experts in Teams is characterized by being highly experiential in its organization. The students are presented with a problem framework within which they have to create a value proposition and qualify that proposition. This innovation process constitutes the learning experience in Kolb’s terminology. Besides the innovation-experience the students also have to learn the importance and difficulty of interdisciplinary team work. This interdisciplinary-team-work-experience becomes a second Kolbian learning experience.

The students typically work in teams of 6. The team is on its own when it comes to identifying and obtaining the knowledge pertaining to innovation content itself. The teacher cannot in general be expected to be an expert within the project framework. The role of the teacher here becomes that of a facilitator.

The students are given tools to aid them in both learning experiences. These tools are presented to them as if they were part of a traditional course curriculum. However, the students are not as such evaluated in their theoretical understanding of these tools. If anything it is the reflection on the usefulness of the tools during their particular experience which is evaluated. Thus the course does not lose its status as experiential over this.

Besides the Kolbian learning experiences mentioned above other characteristics that define EiT as an experiential learning based course were identified and highlighted. The teachers clearly take on the role of a facilitator when they are working with the students on the innovation-process or guiding them on the reflections on the interdisciplinary team work. Finally it was also mentioned how the learning outcomes described in the course description closely fit the expected profile.

With this study I hope to have shed some light on EiT as it is taught at TEK/SDU in Odense. Clearly a course like EiT must always strive not only to adapt to the needs of the business world but also to incorporate the newest knowledge on innovation and interdisciplinary team work. This makes the course highly dynamic and not two semesters will be alike. Ultimately, however, the Kolbian learning experiences of EiT, i.e. the innovation-experience and the interdisciplinary-team-work-experience, will remain the two pillars on which the course is built – otherwise there would be no Experts in Teams.

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# Death by x and y – a mathematician's lament

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Dedicated to class 2.F of 2010-11

## ABSTRACT

The Micro Project is a project assignment to small groups of learners, the outcome of which is an oral presentation (per group) attended by the other groups who supply constructive criticism. In mathematics, at least, it thus departs from the traditional book + lecture + exercise paradigm, which is known to stultify reflection, thus causing the mental 'death by x and y' mentioned in the title. Our collective failure to provide stimuli of mathematical reflection may form part of the cause of The Mathematics Problem, students' inadequate grasp of the mathematics they are assumed to master as they enter university. The Micro Project and experiences with its use in secondary education is described. Various challenges of carrying it over to tertiary education are listed along with suggestions as to how these can be (partially) met.

*Keywords* – action learning, micro project, mathematics teaching

## I INTRODUCTION

It is possible to identify at least three separate, if interacting, sources of motivation leading to the musings of this paper:

- The Mathematics Problem – the gap between the mathematical skills university students are, often tacitly, assumed to possess and those they actually acquire during their years in primary and secondary school
- One sorely neglected thread in the web of reasons behind the Mathematics Problem, namely that we teach mathematics in the wrong way, or at least with an unfortunate bias
- The concept of action learning and one particular realization of it, called Micro Projects for want of a better name – which may to some extent help setting the pedagogical balance right as far as the teaching of mathematics is concerned

All three will be discussed in the following; but emphasis will be on the Micro Projects and the experiences the author had in developing and implementing them. By way of conclusion, the paper offers some reflections on the challenges meeting anyone who attempts to carry Micro Projects from their original setting in classroom teaching in the Gymnasium (the Danish version of High School) to university teaching.

## II The Mathematics Problem

A very substantial literature exists on what has become known as *The Mathematics Problem*, and this is not the place to attempt a serious summary. An informal discussion of selected papers can be found in [12] (Danish) from which we can borrow the following, sufficient for our present purpose.

The Mathematics Problem, very tersely described, consists in the undeniable fact that students arrive at tertiary education – including university education – with an inadequate training in mathematics. This is

sometimes seen as a recent or local challenge and various simple explanations and quick remedies are offered; but in fact, a glance at the literature (as in [12]) will convince anyone with an open mind that:

- The problem is 30-40 years old
- The problem is international
- The problem is truly complex as must indeed its reasons be

Of the many individual causes identified by various writers one can mention

- Inadequate planning within and between primary and secondary school
- Inadequate focus on/handling of the Transition Problem, i.e. the fact that a young person going to university experiences a complete change of environment and in fact of life conditions
- Too little focus on new teaching methods, especially those making use of the computer
- Too much focus on new teaching methods, especially those making use of the computer (-!-)

At least a dozen such observations or claims are made in the serious literature on the problem – with several more in the popular press (many of them uninformed and groundless, but persistent).

It is clear, or so the author thinks, that none of these alleged causes can be held solely responsible for The Mathematics Problem but that they must be seen as interacting. But one possible such element is hardly ever discussed – although it is certainly brought up elsewhere, as the next section will attempt to demonstrate – namely that we may very well be teaching mathematics in the wrong way, not merely in terms of what we focus on, but in the entire conceptualization of mathematics as a subject to be learned.

### **III Do we teach mathematics with our eyes closed?**

There is a wonderful observation ascribed to Pafnuty Chebyshev (-), see e.g. <http://www-groups.dcs.st-and.ac.uk/~history/Quotations/Chebyshev.html>

- To isolate mathematics from the practical demands of the sciences is to invite the sterility of a cow shut away from the bulls

A modern-day Chebyshev, Vladimir Arnol'd, voices a similar opinion in the opening lines of (Arnol'd, V. I. [3]):

- Mathematics is a part of physics. Physics is an experimental science, a part of natural science. Mathematics is the part of physics where experiments are cheap

Arnol'd goes on to criticize the increasing preoccupation with abstraction. Although he is mainly concerned with mathematics at a higher level than that encountered by, say, first year engineering students, he does in fact describe his own - inimitable – experiences with teaching secondary level pupils.

Yet, although there are many wonderful exceptions, many – possibly most – text books used in first-year university mathematics courses contain endless arrays of sterile exercises and no practical examples, no attempts to connect the calculations to the reality known to, and inhabited by, the students.

Even the 1119-page *International Handbook of Mathematics Education* (Clements [8]) devotes only one chapter to mathematical modelling, and a rather dry one at that. In fairness, it should be added that it does

indeed have headlines such as Applicable Mathematics and Modelling for All and ensuing discussions, yet it seems – as far as the present author has managed to delve into it – to accept *status quo*.

So, there is a very real danger that a very large percentage of school children and 1<sup>st</sup> year students will be left with the impression that mathematics is “something to do with solving equations where you have to isolate  $x$ ”.

As for the gradual suppression of ‘applied’ mathematics in favour of the ‘pure’ version, the reader should consult (Maddy [15]). And to avoid painting too gloomy a picture: a collection of cases that actually provides some of what is here wished for can be found in e.g. (Sriraman et al [17])

But there is still more to this, as expressed by e.g. (Klamkin [13])

- I have thought for a long time that one of the most important goals of education is to get the students to ‘think for themselves’. As I look over the American education scene, it seems that each year more and more material is being crowded into the curriculum. The net result being that most students hardly have any time to sit back and think out various problems for themselves. Consequently, most students will ***just parrot back*** the material from their texts or from their classroom notes

(Present author’s emphasis, no offense to *psittacines* intended). A common observation along the same lines is voiced in (Bruckheimer and Gowar [7])

- The traditional emphasis is on technique as an end in itself; on gaining technical facility because that is what is wanted in examinations

An even deeper criticism is that we teach the isolated skills and leave it to the students to work out the big picture themselves – despite the recurrent emphasis of “the beauty of mathematics”, *vide* Hardy.

It would be preposterous to suggest some simple remedy or other; but the next section describes what the author once did and hopes to do again, *mutatis mutandis*.

#### IV Micro-projects

The briefest of autobiographic sketches will provide the necessary background for the description to follow:

**Author’s note:** After graduating as an M. Sc. Eng. in 1983, I was employed by the Technical University of Denmark (DTU) to write a text book on Linear Algebra. I next served as a research assistant at the Dept. of Mathematics, Univ. of Dundee 1984-1988, where during 1987 I also taught numerical solution of ordinary differential equations. Returning to DTU in 1988, I engaged in teaching of, and research in, Graphical Communication, Computer Graphics, programming, Numerical Analysis and various applications of mathematics. Leaving DTU in 2003, I was first employed at the Dept. of Education of the Danish Bankers’ Association, where I served as a project manager responsible for an LMS while also developing an e-learning course in mathematics covering the Danish C-level (essentially 10<sup>th</sup> grade). After 4½ years at NeoConsult Aps., an IT company, as advisor and responsible for HRD, I returned to the world of education, serving as a teacher of mathematics and physics at Lyngby HTX (Danish “Teknisk Gymnasium”) while also maintaining a secondary job as a mathematics tutor at DTU before returning full time to DTU primo 2014. End of note.

While at HTX, which educates 10-12<sup>th</sup> graders, emphasizing technical (and other practical) applications of most disciplines, the author felt compelled to develop modes of presenting mathematical material in a manner transcending the format of conventional exercises. One such was given the category name of *Micro Projects*. It was clearly inspired by earlier work on *action learning*, carried out at the Danish Bankers' Association and documented in (Hansen [11]), with roots further back in the teaching of Graphical Communication at DTU.

A Micro Project can in various ways be distinguished from conventional project assignments:

The class is subdivided into groups of (typically) 3-4 participants, each given a worksheet defining the task they must carry out. There is a common overarching subject, but each group works on a specific topic extracted from this subject. The goal is not a written report but an oral presentation. On the day of presentation, one group at a time is asked to explain its topic to the other groups, receiving immediate feedback in the form of (constructive) criticism from the audience. Typically, one other group is assigned the leading role as examiners. The teacher – the “grumpy corner” – will provide both the facilitation and a few extra comments in case *vox populi* has overlooked something.

A total of 24 Micro Projects in mathematics were planned, 8 per grade. (Similarly, 16 were planned for 10<sup>th</sup> and 11<sup>th</sup> grade physics). Of these, 17 reached the point where all ideas and material were collected, but only 6 were executed, as the author left HTX before the remainder could be carried through. (Of the Micro Projects in physics, 6 were executed, bringing the total of practical experiences with the form to 12, some repeated).

Many of the Micro Projects stayed close to the mathematical subject and were thus glorified exercises, albeit in the theory, rather than the calculations, pertaining to the subject. Yet, as it became clear that the pupils were easily capable of handling complex assignments, ambitions grew. Also, subjects first treated in project assignments were considered for a switch to this more liberal – and often very entertaining – format.

A full list of the subjects and their sub-topics can be made available to any interested reader. Here, two examples are listed in compact form and a further three discussed in more detail below:

Under the heading “Differentiation”, the groups would have been asked to present the topics: 1) Curvature 2) Jounce 3) Taylor’s theorem 4) Implicit functions (including the concept of a contour line) 5) The logarithmic derivative 6) Numerical differentiation 7) Splines and 8) Fractional calculus

(As for the latter, it was first made the topic of a project assignment and as such turned out quite successful despite its being rather advanced). This Micro Project was intended for a 12<sup>th</sup> grade class, but the author left HTX before the appropriate theory had been taught to this class.

In physics, under the heading “Pressure” the groups presented their work on: 1) The pressure under the feet of various animals 2) A pressure boiler 3) A lemon squeezer 4) The bubble 5) The paper ball 6) The diver’s bell 7) The scroll pump 8) The siphon

This latter Micro Project was in fact implemented more than once and showed the ingenuity of the pupils when it came to the use of media such as short film clips, animations and various kinds of acting or role playing

Among the mathematical Micro Projects, we can take a closer look at: the first attempt; a failure; and a success:

The very first Micro Project was assigned to class 2.F of 2010-11 shortly after their first introduction to integral calculus. 2.F, a mathematics-biochemistry class, was small – hence only four sub-topics were needed – and with a wonderful social coherence that made it safe to try out this experiment.

The four topics were: 1) The areas of circular and elliptic annuli 2) Integration of Chebyshev polynomials 3) Various aspects of partial integration as exemplified by antiderivatives of  $x \cdot \cos(x)$  and related functions; and 4) The concept of an integral with a variable limit

Altogether, the experiment was a success, although the pupils indicated quite clearly that this way of working was new to them. A fair amount of guidance had to be provided to make the class understand that this was not an assignment of the ordinary kind, i.e. they were not supposed to present a sequence of calculations but rather to attempt to make their new insight clear to each other. We can let this be

- Lesson 1a: Even when the format is radically different from well-known – and therefore “safe” – modes of learning, a tendency prevails among learners to attempt to squeeze this new mode into better known work patterns
- Lesson 1b: The author had in fact expected that something akin to the Micro Project was very familiar to the pupils from their primary school – but this may have been an ill-founded assumption

The Micro Project soon established itself as a useful way of regularly handing the initiative to the pupils, so when the author took over a Design-Technology class, an attempt was made to introduce vectors and their relations to other mathematical concept via cartography. A selection of mapping projections was made (Mercator's, equi-rectangular, Gall-Peters', sinusoidal, Kavrayskiy's, Aitoff's, Albers', Lambert's and stereographic projection), one given to each team; and the teams were invited to visualize the mechanism and illustrate and discuss the pros and cons of each of these. The necessary tools were made available to them and the work sheets provided links to more information. (This feature became regular when, in the early days, a pupil declared “I couldn't find anything about it on the Internet”. This was quoted, along with the observation that this is equivalent to saying “I was late because the sun didn't rise at its usual time”. Links were provided to English, German and French sources).

The cartography Micro Project was an abysmal failure.

To this day, the author refuses to blame the result on the Micro Project itself, especially since one team actually produced a fine presentation. – But the remaining teams either did not show up or 2 members appeared, claiming that the other 2 had the result of their work – or simply declared that they had not looked at the material. The author later learned that this particular class had a long history of absenteeism, lack of motivation and even a rebellious attitude to the effect that they didn't want to learn this, that or the other.

- Lesson 2a: Micro Projects are not miracle cures
- Lesson 2b: Before implementing a Micro Project make sure the learners are ready for it

And to this section on an optimistic note:

A large class (31 pupils) of 10<sup>th</sup> graders were given a Micro Project on the subject of Extensions of the Number Concept. The sub-topics were

- Numeralia (including e.g. positional notation)
- Spoken words representing numbers (the author habitually asks whether “syttén hundrede og to og halvtreds” is a particularly logical rendering of 1752)

- Fractions, including continued fractions
- The elementary operations of arithmetic with a glance to e.g. the abacus and the *Pascaline*, an early calculating machine
- Algebraic numbers, up to and including the non-solvability of quantic equations in radicals (without proofs...)
- Binary arithmetic
- Matrices
- Complex numbers

It should be added that the worksheets explicitly demanded of the pupils that they identified and discussed at least two questions in addition to those mentioned in the description of the sub-topic.

The result was astonishing. Each group had fearlessly tackled its assignment and gave a presentation that belied the fact that these pupils had only just started their secondary education – some of them were 15 years of age, i.e. children, however much they disapproved of that label.

- Lesson 3a: If you ask the right question, all you must do next is step aside
- Lesson 3b: The amount of talent “out there” is overwhelming

Altogether, developing and facilitating Micro Projects in a school setting was a rewarding experience; but the reader should be warned that the amount of work is considerable.

## V Whither Micro Projects?

It would seem reasonable to attempt to implement Micro Projects in a university setting, but the following issues must be taken into consideration:

- Classes in elementary mathematics are large, often consisting of more than 100 students
- The time allotted to the presentation of background theory of individual topics may be inadequate – for instance, the author currently teaches Oscillation Theory in the span of three weeks
- Although politicians and top managers may be enthusiastic and individual teachers willing to do the work, a peculiar resistance of the “not in my back yard”-type may be encountered from middle managers

As for the first of these, it is a resource question. So far, the author has only been able to rescue the idea of *Contextualization-Decontextualization-Recontextualization* – this choice of wording is taken from (Hansen. H.C. [9]) – by insisting that exercises should not be about “ $x$  and  $y$ ” throughout, but should instead move to authentic models as fast as possible.

Examples: The Hydrological Cycle as source of linear systems (Rose, S. E [16]); Tuned Mass Dampers providing systems of differential equations ([1] Abdelraheem Farghaly, A); Annual variation of radon levels to be treated with least square methods (Arvela, H., O. Holmgren and P. Hänninen [4]); Traces cut by CNC-machines providing nonlinear equations (LIU Qiang\*, LIU Huan, and YUAN Songmei [14]); and many others, even if many of these must be watered down.

The second bullet point above harkens back to the observation by Klamkin, op. cit.: We are forced to squeeze a large curriculum into a narrow time frame. It must therefore be emphasized:



The problem of time allocation is much exacerbated by the fact that we cannot expect the students to master the algebra of the solution processes needed to handle interesting challenges — in other words by The Mathematics Problem

As for the third, which was observed and discussed – but not analyzed or documented – in the EDU-IT project of 1999-2000 (reports are now scattered, but see (Hansen [10])), it is neither mathematical nor pedagogical in nature, yet has a considerable influence on education. It deserves further study, and the interested reader may want to consult (Askling, B and B. Stensaker [5]) or (Blackmore, P. and R. Blackwell [6])

There is still the possibility of introducing the Micro Project in 4<sup>th</sup> term courses or later, where classes are smaller and the curriculum somewhat more flexible. The present author hopes to be able to report on this in the not-too-distant future.

## VI By way of conclusion

Without necessarily accepting the full eight-leaved *competency rose* of (Anonymous [2]), one may at least be allowed to wish for a balanced acquisition of

- Insight into the architecture of mathematics
- Competency in the handling of mathematical models
- Skills in the necessary calculations

Calculational skills can only be acquired by training via exercises. These are the mathematical equivalent of the pianist's scales and arpeggios. But no one would practice endlessly on c-minor scales in parallel sixths or the like without ever playing a real composition and at least hearing a recital or a concert. Likewise, an overdose of calculation without the least reference to either the physical reality or the bigger picture – and preferably both – leads to a Plato's Cave-like idea of what mathematics is about.

By focusing too much on these almost mechanical skills – which we cannot do without but which are not the essence of what we try to teach – we have become dispensers of sterile occupational therapy, merchants of death by  $x$  and  $y$ .

We need a lot of alternative ways of presenting our discipline. The Micro Project and the experiences it brought with it is but one of many possible such. Although a bit exaggerated, one may paraphrase Cato the Elder:

PRAETEREA CENSEO EXERCITIONEM ARITHMETICAM ESSE PRAETERMITTENDAM

and take it from there.

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I would like to thank class 2.F of 2010-11 for providing the inspiration and the high spirited environment that made possible the first experiments with Micro Projects. – And mag. art. Helle Gjellerup for translating “Besides, I think number gymnastics should be abolished” into Latin. —

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# **TEACH FOOD – Developing a teacher’s community of practice**

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## **ABSTRACT**

The National Food Institute (DTU FOOD) at DTU teaches and educates engineers for the food sector, the public authorities and the research communities. To meet these objectives faculty needs to be at the forefront of food science as well as in teaching and continuously develop the approach to how to teach. Learning environments with suitable student challenges requires devoted and involved faculty members, who continuously develop their competences in teaching. At DTU FOOD the faculty consists of scientist in a broad range of disciplines and cultures. TEACH FOOD was established to promote and enhance the development of community of practice, i.e. a Professional Learning Community (PLC) focusing on optimizing the learning outcome of the students. To achieve this, a 1½ residential seminar for all teachers was arranged. In the first seminar 76% of the teachers and the head of institute participated. Five core activities were identified and a series of half years seminars were started focusing on challenges in every day teaching experiences. The participation of DTU FOOD faculty members in the internal DTU conferences about teaching and learning has increased from 3 to 11 since the start of TEACH FOOD. These activities illustrate the extended willingness to discuss teaching and learning as well as share experiences from teaching at DTU FOOD exemplifying the growing PLC.

*Keywords* - Professional Learning Community, exchanging and sharing teaching experiences, development of teaching

## **I INTRODUCTION**

### **DTU teaching structure**

The Technical University of Denmark (DTU) educates around half of all engineers in Denmark. It is a single faculty university with 23 institutes and one centre (Centre for Oil and Gas – DTU). DTU has three campuses with the main campus in Lyngby. At DTU education in Bachelor of Engineering (B. Eng) (17 programs) and Bachelor of Science (B.Sc.) (18 programs) and Master of Science (M.Sc.) (28 programs) are taught. The B.Eng. programs are aligned with the international teaching concept CDIO (Conceive-Design-Implement-Operate) (Crawley et al 2007) where a predefined study plan is given with little

flexibility for the students, to ensure a complete integration of CDIO. For the B.Sc. and M.Sc. about a fourth of the course can be chosen individually.

At DTU students have approximately 20 teaching hours a week and are expected to devote around 45 hours a week for their study corresponding to full time study. DTU have introduced the “red dot project” (Hansen, C.T. et al 2014) transforming students from pupils to students acknowledging their responsibility for own learning. DTU support cross-disciplinary projects where students work as engineers solving real life problems. This is called Blue Dot (Blue Dot, 2017). Blue Dot projects are extra curriculum activities where knowledge is put into action creating real products that can be tested. The learning objectives of Blue Dots are to work independently and creative using principles of engineering and theories based on up to date methods.

### **DTU course evaluation and teacher training**

All courses are evaluated by students at the end of the course, after exam and during the course. The two first evaluations are sent to the institute study board and commented; the last is used for adjustment of courses during the semester. At many institutes the evaluation function as a quality assurance of teaching and learning.

All teachers at DTU have to take a mandatory teacher training programme (UDTU) in order to become associate professors or have full course responsibility. This is given by LearningLab DTU (DTU LLab). DTU LLab is the main support function on teaching and learning and aim at inspiring and support teachers, students and management at DTU. DTU LLab contributes to development of the quality of study programmes, teaching and learning at DTU and draws on a large network both in Denmark and internationally (LearningLab 2017). Teacher’s training and teaching development at DTU is based on the idea of “Scholarship of Teaching & Learning”. In brief, this means that a faculty member works professionally with continually develop and improve own teaching practice and evaluate the outcome in order to understand how to improve. For staff with a long teaching experience at university level and which have been course responsible for some years but still are missing a structured training in teaching and learning “University Pedagogy for Experienced Teachers” (UP) exists and have the same objectives and content as UDTU. An educational coordinator at each institute trained by DTU LLab, coordinates the didactic training at the institute with special emphasis on newly appointed assistant professors, and make sure that they are enrolled at UDTU and are awarded an educational supervisor. The educational supervisors supervise and evaluate the new staff’s teaching qualifications and potentials with feedback to , DTU LLab.

### **Background at DTU FOOD**

Ten years ago, research institutes in Denmark were merged into existing universities to enhance the teaching capacity at university. It was politically decided that DTU FOOD, should be merged into DTU, whereby researchers with little or no background in teaching was transferred to an educational institution hereby becoming teachers and here had the opportunity to be educated in new teaching principles by DTU LLab and experience teaching without prejudice and focus on old tradition in how to teach.

DTU FOOD teaches and educates engineers for the food sector, the public authorities and the research communities. The focus areas are prevention of disease and promotion of health as well as making it possible to feed the growing population and development of a sustainable food production. This creates a common domain for teaching and learning.

The strategic objectives for teaching at the DTU FOOD has since 2015 been to increase recruitment to the Master's degree in Food Technology and further development and optimization of the three existing study programs with high quality teaching. To meet these objectives faculty needs to be at the forefront of food science as well as in teaching and learning continuously development of all three education programs, namely the Master in Food Technology, the Bachelor of Engineering (Food Safety and Quality) and the Bachelor of Science (Food and Nutrition) based at Copenhagen University to recruit motivated students. Learning environments with suitable student challenges requires devoted and involved faculty members, who continuously develop their competences in teaching and learning (Vescio, V. *et al.* 2008).

## **TEACH FOOD**

To face the DTU FOOD objectives and needs for faculty development, the director in 2015 set terms of reference. The TEACH FOOD project was initiated to strengthen the teaching at the institute. DTU FOOD faculty consists of scientist in a broad range of disciplines, embracing food aspects from technology, microbiology, toxicology, chemical analysis, nutrition to risk assessment.

TEACH FOOD was created to encourage discussion on teaching issues, study programs and to cooperate and improve the understanding of students learning. The overall aim for TEACH FOOD was therefore to create a community of practice (Wenger, E., 1998), i.e. a Professional Learning Community (PLC) (Vescio *et al.*, 2008) focusing on optimizing the learning outcome of the students (Wenger, E. 1998). Communication among faculty members should also aim at development and optimization of the three study programs included at the institute. Inspiration for this work to create a PLC was gained from a similar, but not identical, project some years ago at the former institute of DTU Systems biology (Hellgreen *et al.* 2011).

Here an attempt to create an overview of present status is presented. By continuously focus on creating a community of practice at DTU FOOD, TEACH FOOD assume that deeper learning for students and improved knowledge sharing among the faculty will be the outcome, for the better of society.

## **II HYPOTHESIS/PROBLEM STATEMENT**

DTU FOOD is faced with two important scenarios. The first scenarios are to change the given courses from traditional lecture based to courses with student involvement and – engagement. By changing the focus from the lecture to the students, changes are necessary and the teacher should be willing to “let go of control” leaving the responsibility for the learning outcome to the student (Ulriksen, L. 2014). This is in alignment with the DTU project red dot (Hansen, C.T et al 2014) where the responsibility for achieving deeper learning is transferred from the teacher to the students so they become capable students and not pupils for whom learning is connected to the teacher. The teacher's role is then transferred to be facilitators of learning outcome. To do so, changes are needed and modern teaching philosophy and methods should be used for enhanced learning and alignment of evaluation (Biggs and Tang, 2001). Furthermore, students will have to engage more active in the teaching when changes are made presumably leading to deeper learning. This framework will have to be established finally when the institute is moved to the central campus of DTU here in 2017, leading to a broader exchange of information and knowledge in faculty.

Secondly, DTU FOOD was merged with DTU now ten years ago. Before the merge teaching was not a primary focus area in the institute leaving teaching to be done, when time was available. This has now changed and a building of a society of teachers exchanging information concerning how to teach without fearing supervision is needed. Teaching is presently still something done individually with little knowledge exchange between fellow members of the faculty. This leads to a feeling of loneliness when dealing with problems as how to teach. Due to today evaluation of teaching is highly focused on the student perspective, the teacher can find him/her isolated and having difficulties in sharing problems encountered. By having focus on these two areas, we believe that deeper learning for students will be the outcome we hypothesize.

### **III THEORETICAL FRAMEWORK**

Communities of practice are formed by people who engage in a process of collective learning in a shared domain, here as teachers working for student deep learning in DTU FOOD study programs. This group share a passion and learn how to do it better as they interact regularly (Wenger, E. 2006). Three characteristics are crucial for a community of practice (Wenger, E 1998):

1. The domain
2. The community
3. The practice

First, the community of practice needs a shared domain of interest as a defined identity (Wenger, E. 2006). The teachers at DTU FOOD share commitment to student learning and own teaching practice development throughout their daily teaching and general training at either UDTU or UP. This community differs from the established community of research which aligns with the line of command. Teaching is cross-disciplinary between the departments in the institute. By TEACH FOOD, we established the second requirement, the community, who shares interests in student learning and continuously practice development are pursued by joint activities, discussions, shared information and helping each other. This support the movement from “feeling alone” to being part of a shared community working for improved education. The final requirement with a shared repertoire of resources, experiences, tools and ways of addressing recurring challenges sums up to a shared practice. This will be established through knowledge sharing and discussions at DTU FOOD at bi-annual teacher seminars.

The perspective of communities of practice affects educational practices along three dimensions:

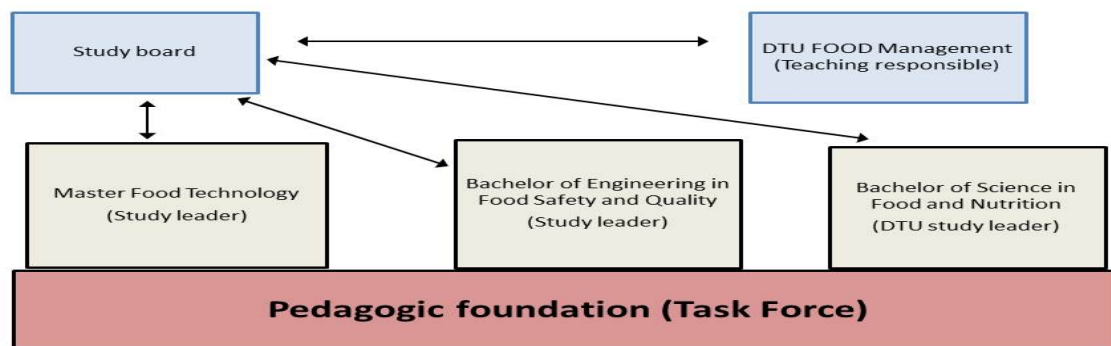
1. Internally. By designing track for progressing of learning visual for the students and create cross-disciplinary course where students from multiple study program solve real life scenarios leading to motivated students (see also innovation).
2. Externally. By close cooperation with students hubs of innovation (DTU SKYLAB, 2017) and extra curriculum activities that are align with study program given the student opportunities that can lead to a “Blue Dot” diploma (Blue Dot, 2017). Finally, all education at DTU has advisory groups including representatives of industry setting the framework for competences in the study lines.
3. Lifelong learning needs continuing interest from the students. The university is in this context only part of a broader learning system. The University is not the primary learning environment. That is life in itself and the university creating alumni networks, graduates retain contact to the established learning environment at the university, hereby creating a symbiotic network of knowledge exchange (Wenger, E. 2006). Using “Authentic Learning” in complex scenarios an entrepreneurial mindset will be created and focus will not only be on Start-Ups (Fayolle, A. and Gailly, B. 2008).

Few empirical data have documented that learning community's support student learning (Vescio et al., 2008). The most significant factor for student learning is teaching quality, which is improved by continuous professional learning (Hord, S.M. 2009). The concept of a PLC rests on the premise of improving student learning by improving teaching practice (Vescio, V. *et al* 2008). Research support the idea that participation in a learning community lead to changes in teaching practice. When PLC is created a common core group is often identified (Wenger, E 2006). At DTU FOOD, TEACH FOOD represents this.

#### IV DISCUSSION

TEACH FOOD was divided into 4 minor projects (see figure 1), one for each study program and one for pedagogical development and establishment of a PLC. The last one formed a Task Force with two study leader, and the pedagogical coordinator at the institute. This paper describes work in progress. Since the introduction in 2015, implementation of the focus areas has been done gradually and here we attempt to show evidence of the ongoing process and its effect on teaching and learning. Implementation of e.g. course changes is delayed due to the standard procedures. This focus will be on creating the PLC and how this has and will improve teaching at DTU FOOD.

The Task Force, a representative from Human Resources and a representative from DTU LLaB planned a 1½ days residential seminar for teachers. The institute director and 35 employees (75% of the faculty) participated in the first seminar, facilitating a collective reference for faculty. This first seminar encouraged teachers to talk together across scientific disciplines and the main part of participants experienced teaching develop from loneliness to exchange of experiences and knowledge. Identification of core activities in TEACH FOOD resulted in the following five main activities included in the project time frame on figure 2.



*Figure 1: Organization of TEACH FOOD. At the top level we find management of course structure (study board) and resources management (head of institute). The three study lines are included in the middle and all are based on the pedagogic foundation. Responsibilities are in brackets.*

Tools were identified from the discussions on teaching and learning at the seminar as a lot of case stories from industry and authorities available for application in teaching problem and case based (De Graaf, E. and Kolmos, A. 2003) .

#### Development of the study lines

The first crucial step (figure 2) for obtaining motivated and well-trained students were identified at the residential seminar to ensure transparent development of the three study programs. For each of the three study programs, the appointed study leader created series of meetings where content of courses and progression of teaching and learning are debated. Overlap in course content was identified and reduced. By creating individual communities of practice for each education program and involving all course responsible, information has been shared and understanding of the progression identified

The concept of a competence matric, obtained from CDIO (Crawley, E. et al 2007) was applied in M.Sc. for the development of two study specialization. At M.Sc. two courses are obligatory for all candidates. One of these courses (course no. 23101) has been adapted to include more broad and general competences essential for both specializations.

Competence matrices for personal and professional competences have been redesign in the B.eng. according to adjustment in the study program and each course responsible has given their contribution. This has been aligned to identify what courses contribute to the final learning objectives of the education. Increased average grade (from none to 5.9) for the 40 students indicate a raised interest in this study program from 2013 to 2016 among students.

For B. Sc. where study line responsibility is at KU, focus has been on creating a new important cross disciplinary course at the first semester and showing progression in food technology from this course to DTU courses taught on fifth semester.

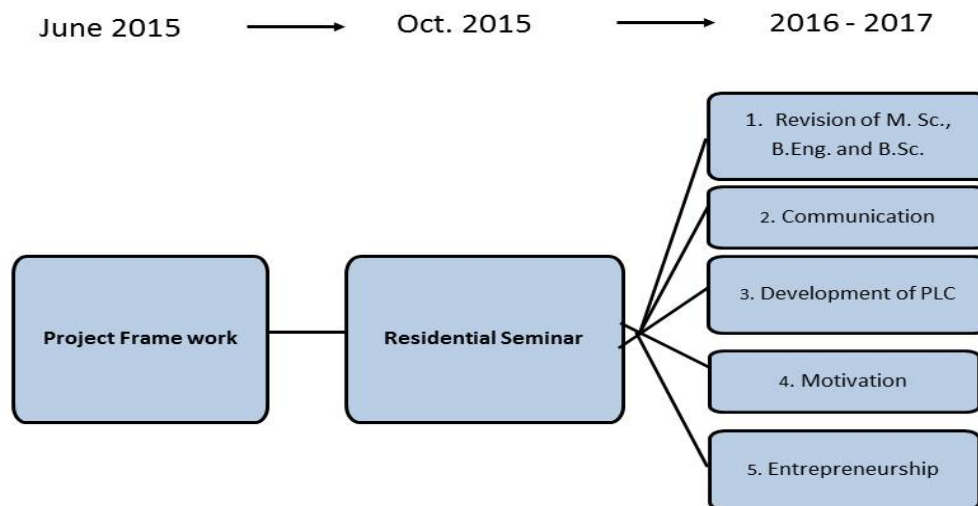


Figure 2: Time frame for TEACH FOOD with the five core activities. The project will end in 2017 and the core activities will continue based on teacher motivation.



## **Communication**

The second activity identified were a need for a clearer profile for each study program, both internally and externally. The first result of the seminar was a name change for the B.Eng. from “Food analysis” to “Food safety and quality” hereby focusing on what the student learn and not what they do. Among the student this change has been achieved positively and they now understand the learning objective of the education. The name has made it easier for industry to understand what graduates can do and to differentiate these graduates from other education programs in Denmark. A course of fifth semester has been changed to sensory evaluation, a discipline requested by the advisory board for this education.

The teaching responsible at DTU FOOD has initiated a communication strategy for all study programs for students and future graduate employers. The work which will be launched in autumn 2017 has included involvement of study leaders, study board, task force and communication personnel at DTU FOOD.

## **Development of PLC**

The Task Force has planned and coordinated biannual ½ day seminars for faculty members. For each of these meetings approximately half of the faculty participates including full professors. The shared interest in student learning and continuously practice development by these joint activities, discussions and shared information and knowledge were believed to establish a shared community of practice working for improved education at DTU FOOD (Wenger, E., 1998).

The first meeting was held in March 2016 with focus on exams. Representatives from DTU LLab introducing the theory followed by lively discussions on how to establish exam activities corresponding to learning objectives. The seminar inspired the teacher in food chemistry (23302) to change the exam to include overall open questions covering curriculum for the students to apply own examples prepared in advance instead of randomized questions with no prior idea on what is relevant from the curriculum. This increase the student learning due to an increased focused preparation for the exam at a higher level of Blooms taxonomy (Anderson et al., 2001). Results will appear in June 2017.

The second seminar in September 2016 included ideas and inspiration on student midterm evaluation with a practical example from a teaching situation. Emerging teaching technologies were presented with an example of development of a Coursera e-learning course. Active discussions and questions to the presenter indicated interest and willingness to adapt new technology and techniques in own teaching.

At the third seminar in March 2017 a discussion on career framework (Career Framework, 2017) and teaching portfolio development were discussed. Methods of quantitative measuring increased student learning were lively discussed with suggestion on use of e.g. exam grades, student pre- and post-tests as well as student course evaluations. The study board will look into if evaluations can be used. At the meeting it was suggested that extra curriculum activity required for UDTU participants could be used as an inspiration to the DTU FOOD teachers. The language in student approach was discussed as an attempt to establish practices in the community (Wenger, E. 1998). Teachers have some difficulties when addressing students as kinsmen/engineers (not so well trained) or pupils. Students often complain and feel that teachers look down upon them and do not recognize them.

Input for seminar topics has until now come from the Task Force. At the recent seminar faculty members started to come up with ideas on topics relevant for seminars in the future. Next seminar in September includes a presentation of use of personality evaluation for establishment of project groups at M Sc.

The DTU FOOD faculty members participating in the internal DTU conferences about teaching and learning have increased from 3 to 11 since the start of TEACH FOOD: Twice has DTU FOOD been among DTU institute with most faculty attendees. For the newly established “development of teaching” prize a member of the faculty at DTU Food was the runner up in fall 2016. In addition at least two faculty members from the DTU FOOD contribute with presentations at the internal DTU conference every time.

### **Motivation**

Involvement and increased focus from DTU FOOD management with visually recognition of teaching and teachers has increased focus on student teaching and learning at the whole institute. News on teaching are presented at quaternary presentations by the head of institute. Last year the task force members were presenting their motivation for teaching and learning at the yearly institute day. Since then, this group has experienced that colleagues have increased interest in teaching and learning realized as frequent questions and interest in e.g. student projects. It is acknowledged, that colleagues find it inspiring to teach. The recognition and visualization of teaching results in more motivated teachers indicated by even professors participate in teacher seminars and willingness to discuss teaching practices.

### **Entrepreneurship**

Entrepreneurship should be included in relevant courses and be transparent for students. Courses part of the master education curriculum has been tweaked to result in a clear progression in innovation and entrepreneurship. These allow the student to take innovative ideas generated in courses at the beginning of their education and work with them through the following courses. Different courses in the study plan supplies the necessary engineering competences that can be put into play in this *wheel of innovation* that also include extra curriculum activities in cooperation with SKYLAB (SKYLAB 2017) and finalizing in Blue dot diplomas (Blue Dot., 2017). The number of students taking courses in this *wheel of innovation* has gradually improved from 78 in 2007 to 95 in 2016 and money has been granted by the Danish entrepreneurial fond to create a national competition in food innovation. The first student spin-off company was registered in fall of 2016

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## VI CONCLUSIONS

A PLC is developing at the DTU FOOD. After increased focus from the DTU FOOD management and establishment of TEACH FOOD colleagues are after one and a half year already discussing teaching in the hall, at the cantina, and at the DTU FOOD biannual workshops with approx. 50% of all faculty members participating each time.

Study leaders have included relevant faculty in a systematic establishment of course matrixes similar to international CDIO principles for the study programs related to student competences and engineering abilities according to Blooms taxonomy.

Student evaluations of all courses at DTU FOOD are good and the community work continuous the development of knowledge based sharing and practices for student activation and evaluation. Measurement of student learning are ongoing and increasing in number.

Entrepreneurship and innovation has been integrated in courses both at the B.Eng. and M.Sc. and progression have been visualized by the wheel of innovation. Student participation in these innovations courses is gradually increasing.

Activities during biannual seminars at DTU FOOD and internal at DTU Teaching and learning conferences illustrate the extended willingness to discuss teaching and learning and share experiences from teaching at DTU FOOD. At the same time the DTU FOOD Director refers to teaching at her quarterly summaries and acknowledged teachers efforts and student satisfactory on courses and projects at the yearly summary. TEACH FOOD is developing and future perspectives are inclusion of other employees than faculty at DTU FOOD.

## **VII ACKNOWLEDGEMENTS**

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### **BIOGRAPHICAL INFORMATION**

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Håkan Vigre is the study leader of the Master education in Food Technology at DTU FOOD. He is course responsible and teaches several courses on risk assessment. He is part of Task Force for TEACH FOOD.

Pernille Hammar Andersson is educational consultant at Learning Lab, DTU. She works in the office for Study Programs and Student Affairs and is responsible for the mandatory teacher training program UDTU as well as other teacher training initiatives at DTU. She coordinates the network of pedagogical coordinators and work with a wide range of projects with aim to develop teaching and learning at DTU.

Lars Bogø Jensen is head of the Study board at the National Food Institute and study leader for the B. Eng. education “Food Safety and quality” He is course responsible for first year course on microbiology and food technology, part of the Task Force for TEACH FOOD, and participates in meetings in the DTU’s “netværksgruppe for universitetspædagogik”





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